The world's most comprehensive encyclopedia of the military weapons of the 20th century

WAR MACHINE

An ORBIS Publication

28

80p

IR £1 Aus $1.95 NZ $2.25 SA R1.95 Sing $4.50 USA & Can $1.95

USAF
956
U.S. AIR FORCE
U.S. AIR FORCE

Reconnaissance over the Battlefield

Reconnaissance Sensors

Armed Forces of the World: French Navy

Lockheed SR-71 in Action

A fully illustrated guide to Strategic and Tactical Reconnaissance Aircraft

WAR MACHINE

Volume 3 **Issue 28**

CONTENTS

Strategic and Tactical Reconnaissance Aircraft

Dassault-Breguet Mirage IIIR 542
Dassault-Breguet Mirage F.1CR 542
SEPECAT Jaguar 543
BAC Canberra 544
Aeritalia G91R 544
Grumman OV-1 Mohawk 545
Lockheed F-104 Starfighter 546
Lockheed U-2/TR-1 547
Lockheed SR-71A 548
Lockheed SR-71 in Action 548
Reconnaissance Sensors 554
McDonnell Douglas RF-4 Phantom 554
Reconnaissance over the Battlefield 556
Northrop RF-5 558
Saab 35 Draken 558
Saab-Scania Viggen 559
Mikoyan-Gurevich MiG-21R 'Fishbed' 559
Mikoyan-Gurevich MiG-25R 'Foxbat' 560

Armed Forces of the World

French Navy iii

Published by
Orbis Publishing Ltd
© Aerospace Publishing Ltd 1984
Colour profiles, diagrams and cutaway drawings © Pilot Press Ltd

Editorial Offices
War Machine
Aerospace Publishing Ltd
10 Barley Mow Passage
London W4 4PH

Managing Editor: Stan Morse

Editorial: Trisha Palmer
Chris Bishop
Chris Chant
Design: Rod Teasdale
Colour Origination: Imago Publishing Ltd, Thame, Oxon
Typesetting: SX Composing Ltd
Film work: Precise Litho Ltd

Artists:
Keith Fretwell
Keith Woodcock

Consultant Editor: Major General Sir Jeremy Moore KCB OBE MC, Commander of British Land Forces during the Falklands campaign.

15843

Printed in Great Britain by The Artisan Press Ltd

Distribution and marketing offices:
Orbis Publishing Ltd
Orbis House
20-22 Bedfordbury
London WC2N 4BT
Telephone: 01-379 6711
Circulation Director: David Breed
Marketing Director: Michael Joyce

WAR MACHINE
Price UK 80p. IR £1. Aus $1.95. NZ $2.25. SA R1.95. Singapore $4.50. USA and Canada $1.95

How to obtain your copies of WAR MACHINE: Copies are obtainable by placing a regular order at your Newsagent, or by taking out a subscription.

Subscription Rates
For six months (26 issues) £23.80; for one year (52 issues) £47.60. Send your order and remittance to Punch Subscription Services, Watling Street, Bletchley, Milton Keynes, Bucks MK2 2BW, being sure to state the number of the first issue required.

Back Numbers
UK & Eire: Back numbers are obtainable from your Newsagent or from WAR MACHINE Back Numbers, Orbis Publishing Limited, 20-22 Bedfordbury, London WC2N 4BT at cover price.

Australia: Back numbers are obtainable from WAR MACHINE Back Numbers, Gordon & Gotch (Aus) Ltd, 114 William Street, PO Box 767G, Melbourne, Vic 3001.

South Africa, Europe, Malta and New Zealand: Back numbers are available at cover price from your Newsagent. In case of difficulty write to the address in your country given for binders. South African readers should add sales tax.

How to obtain binders for WAR MACHINE

UK & Eire: Send a cheque or Postal Order for $3.95 per binder (incl p & p) payable to Orbis Publishing Ltd to WAR MACHINE Binders, Orbis House, 20-22 Bedfordbury, London WC2N 4BT

Europe: Write with remittance of £5.00 per binder (incl p & p) payable to Orbis Publishing Ltd to WAR MACHINE Binders, Orbis House, 20-22 Bedfordbury, London WC2N 4BT.

Malta: Binders are obtainable through your local Newsagent, price £3.95. In case of difficulty write to WAR MACHINE Binders, Miller (Malta) Ltd, M.A. Vassalli Street, Valletta, Malta.

Australia: For details of how to obtain your binders see inserts in early issues or write to WAR MACHINE Binders, First Post Pty Ltd, 23 Chandos Street, St Leonards, NSW 2065. The binders supplied are those illustrated in the magazine.

New Zealand: Binders are available through your local Newsagent or from WAR MACHINE Binders, Gordon & Gotch (NZ) Ltd, PO Box 1594, Wellington.

South Africa: Binders are available through any branch of Central News Agency. In case of difficulty write to WAR MACHINE Binders, Intermag, PO Box 57394, Springfield 2137.

Note: Binders and Back Numbers are obtainable subject to availability of stocks. Whilst every attempt is made to keep the price of the issues and binders constant, the publishers reserve the right to increase the stated prices at any time when circumstances dictate. Binders depicted in this publication are those produced for the **UK market only** and may not necessarily be identical to binders produced for sale outside the UK. Binders and issues may be subject to import duty and /or local taxes, which are not included in the above prices unless stated.

The WAR MACHINE published by Orbis Publishing Ltd has no connection with the WAR MACHINE published by Emjay. The latter is a magazine devoted to computer simulation gaming and further information and subscription details can be obtained from Emjay, 17 Langbank Avenue, Rise Park, Nottingham NG5 5BU, England.

Picture acknowledgements

Cover photograph: Lockheed. **541:** Lockheed/US Air Force. **542:** Dassault-Breguet/Dassault-Breguet. **543:** Peter Foster Collection/Peter Foster Collection. **544:** Bob A. Munro. **545:** Aeritalia/Grumman. **546:** Grumman. **547:** US Air Force/US Air Force. **548:** Lockheed. **549:** Lockheed. **552:** Lockheed/Lockheed. **553:** Lockheed. **555:** McDonnell Douglas/Denis J. Calvert. **559:** Saab-Scania. **(iii):** Aeronavale. **(IV):** Aeronavale.

WAR MACHINE
Forthcoming issues feature:
Modern Nuclear Attack Submarines
Armoured Vehicles of World War I
Modern Cruisers
Armoured Cars of World War II
Air-to-air Missiles

Strategic and Tactical Reconnaissance Aircraft

Possibly the most sinister shape in the sky today, the SR-71 represents the height of technology, showing how important reconnaissance is to the military.

Reconnaissance has played an important part in recent warfare, and the battles of tomorrow will rely even more on this branch of the aerial forces. Reconnaissance aircraft have had to find ways to overcome constant developments in anti-aircraft systems by means of speed and countermeasures.

It is a truism that one of the prime requisites in waging war successfully is that of knowing what your opponents' intentions are, precisely what forces he has at his disposal and, perhaps more importantly, how they are dispersed. Such information, collectively known as 'intelligence', can be obtained in a variety of ways, one of the most effective methods now in use being aerial reconnaissance, which is a much more diverse subject than might at first be thought.

For a start, aerial reconnaissance falls into two main areas of activity, namely strategic and tactical, and can be accomplished in any one of several different ways by a variety of tools. Since it is more concerned with the long-term picture, strategic reconnaissance is now very much the preserve of what are euphemistically known as 'spy satellites', and there is as yet no effective means of countering these although the US Air Force is working on an anti-satellite missile and one must presume that Soviet efforts at perfecting similar devices are not lagging far behind. In addition, however, strategic reconnaissance can be, and most emphatically is being, accomplished by manned aircraft. Few of the types engaged in such duty are examined here since much of their mission entails 'snooping' and listening out for Elint (electronic intelligence) and Sigint (signals intelligence). In the US Air Force this is mainly accomplished by variants of the Boeing C-135 Stratotanker whilst the Soviet Union generally employs converted bomber types such as the Tupolev Tu-16 'Badger' and Tu-95 'Bear', and in the UK there is the BAe Nimrod R.Mk 1.

Without doubt the most impressive strategic reconnaissance tool is the Lockheed SR-71A 'Blackbird', a type which is studied in this survey since it can also contribute significantly to the near-term view, more generally the domain of tactical reconnaissance types such as the McDonnell Douglas RF-4C Phantom, Mikoyan-Gurevich MiG-21R 'Fishbed' and Dassault-Breguet Mirage IIIR, all of which are concerned predominantly with acquiring intelligence relating to events on the field of battle.

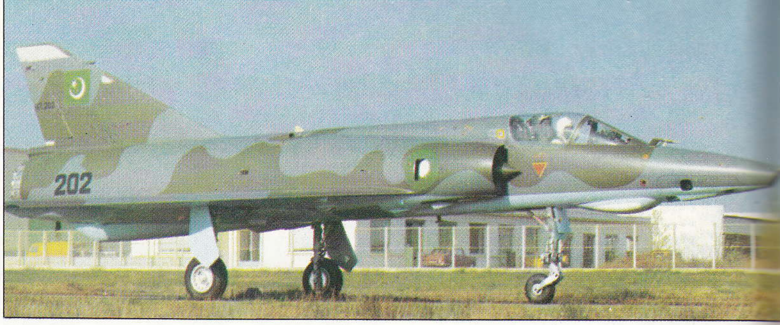
Improvements in aircraft performance have been matched to a degree by improvements in reconnaissance systems, but many readers will probably be surprised to learn that the trusty camera shooting black and white film is still the most universally used tool in conveying intelligence to field commanders. In an era when the video camera is king, this is particularly surprising although, in fairness, it should be pointed out that the cameras employed are rather different from the average household 'instamatic', whilst vigorous efforts are being directed towards finding alternative methods of both obtaining and circulating reconnaissance data.

Finally, however, strategic and tactical reconnaissance aircraft complement each other in ascertaining the 'big picture', and neither should be neglected in favour of the other or as a short-term sop to those who seek to restrict defence spending. In its simplest terms, trying to wage peace or war with a lack of good reconnaissance and intelligence facilities equates closely to the blindfolded man searching for a black cat in a darkened room: he knows it is there somewhere, but he is not sure just where.

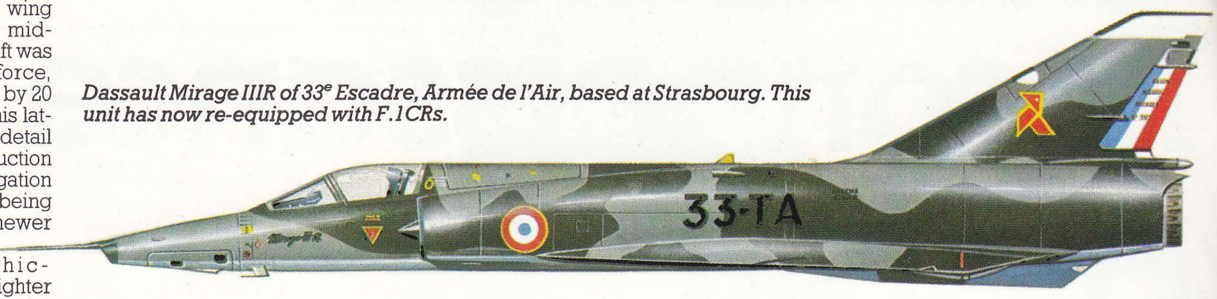
From the same stable as the SR-71 is the Lockheed TR-1. Derived from the earlier U-2, its role has changed from strategic to tactical reconnaissance from a stand-off position on the NATO side of Warsaw Pact frontiers.

FRANCE

Dassault-Breguet Mirage IIIR



As well as receiving Mirage III interceptors, Pakistan also purchased 13 Mirage IIIRP reconnaissance variants, distinguished by the redesigned nose housing various forward, downward and sideways-looking cameras.



Dassault Mirage IIIR of 33^e Escadre, Armée de l'Air, based at Strasbourg. This unit has now re-equipped with F.1CRs.

Evolved from the definitive Mirage IIIE tactical strike fighter, the **Dassault-Breguet Mirage IIIR** first flew in prototype form on 31 October 1961, with production aircraft beginning to replace the Republic RF-84F Thunderflash in Armée de l'Air service at Strasbourg during the course of 1963, all three *escadrons* of the parent wing eventually converting by the mid-1960s. An initial batch of 50 aircraft was acquired by the French air force, these subsequently being joined by 20 examples of the **Mirage IIIRD**, this latter variant featuring a number of detail changes over the original production model, such as an improved navigation radar. These aircraft are now being progressively replaced by the newer Mirage F.1CR.

Like most photographic-reconnaissance derivatives of fighter aircraft, the Mirage IIIR has a redesigned nose section, deletion of the Cyrano II fire-control radar permitting the installation of up to five cameras for day or night operation. To permit armed reconnaissance missions to be undertaken, the Mirage IIIR can be equipped with two 30-mm DEFA cannon, and it is also able to carry various types of ordnance underwing, the pilot being provided with a reflector gun sight and low-altitude bombing system equipment to assist in weapons delivery.

In addition to those aircraft acquired for service with the French air force, reconnaissance models of the Mirage have found favour overseas, close to 100 being built for the export market. These include variants of the Mirage IIIR for Pakistan (13 **Mirage IIIRP** aircraft), South Africa (eight **Mirage IIIRZ** aircraft) and Switzerland (18 **Mirage IIIRS** aircraft) plus numerous examples of reconnaissance-configured Mirage 5s, the latter being a simplified Mirage intended specifically for export. Customers for the **Mirage 5R** include Abu Dhabi, Belgium, Colombia, Egypt, Gabon and Libya which between them have taken delivery of approximately 50 aircraft, most of which are still in use today.

Specification

Mirage IIIR

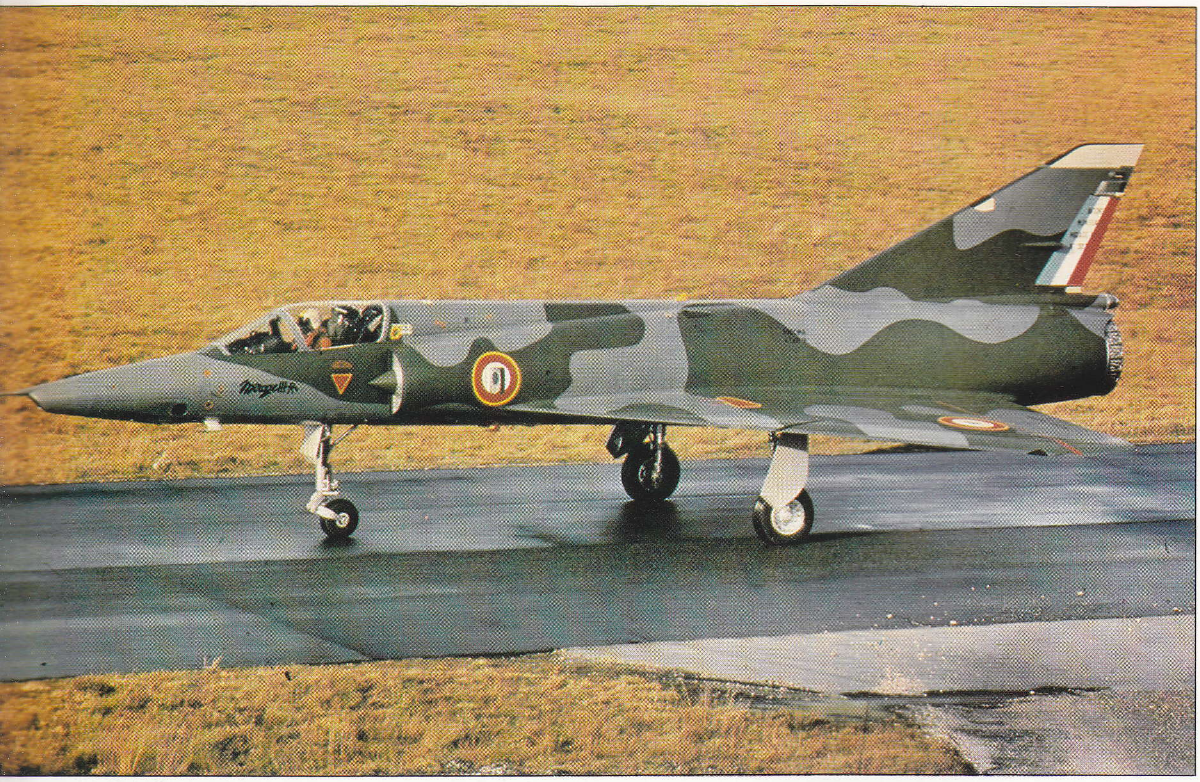
Type: single-seat tactical reconnaissance aircraft

Powerplant: one SNECMA Atar 9C turbojet rated at 6200-kg (13,670-lb) afterburning thrust

Performance: maximum speed at sea level 1390 km/h (863 mph) or Mach 1.14; maximum speed at altitude 2350 km/h (1,460 mph) or Mach 2.2; range in clean condition about 1600 km (1,000 miles); ferry range with full external fuel 4000 km (2,485 miles)

Weights: empty 6600 kg (14,550 lb); maximum take-off 13500 kg (29,760 lb)

Dimensions: span 8.22 m (27 ft 0 in); length 15.50 m (50 ft 10¼ in); height 4.25 m (13 ft 11½ in); wing area 35.00 m^2 (377 sq ft)



This is the development aircraft for the Mirage IIIR programme, involving removing the nose fire control radar (Cyrano II) and replacing this with cameras. The airframe was the same as the standard model, and weapons can be carried.

FRANCE

Dassault-Breguet Mirage F.1CR

Flown for the first time in prototype form shortly before Christmas Day 1966, the **Dassault-Breguet Mirage F.1** has proved to be almost as versatile as the Mirage III which preceded it, being able to undertake a multiplicity of missions including air superiority, tactical strike, ground-attack and, more recently, tactical reconnaissance.

Initial production examples of the basic F.1C all-weather interceptor model entered service with the French air force during the course of 1973 and this type has also met with considerable success on the export market, customers including Ecuador, Greece, Iraq, Jordan, Kuwait, Libya, Morocco, South Africa and Spain. It seems likely that manufacture of variants of the Mirage F.1 will continue until at least 1987, several hundred now being on order or in service throughout the world.

The specialized reconnaissance model is the **Mirage F.1CR**, and this is now in process of replacing the 50 or so Mirage IIIR/RD aircraft which equip the 33^e Escadre at Strasbourg, the French air force's sole tactical reconnaissance unit. Selected in February 1979, two Mirage F.1CR prototypes were produced for test duties, the first making its maiden flight on 20 November 1981. These two machines are being followed by 62 production examples, deliveries of the first to the 33^e Escadre having begun fairly recently.

Mission-related equipment includes OMERA cameras carried internally together with an infra-red sensor, while additional electromagnetic or optical sensors can be housed in an external pod fitted beneath the aircraft's belly. Air-to-air missiles can also be carried for defensive purposes, while inflight-refuelling gear is also fitted as standard.

Thus far, the reconnaissance variant has not been ordered for export but, in view of past sales successes, it would seem reasonable to assume that some overseas customers will acquire this model in due course.

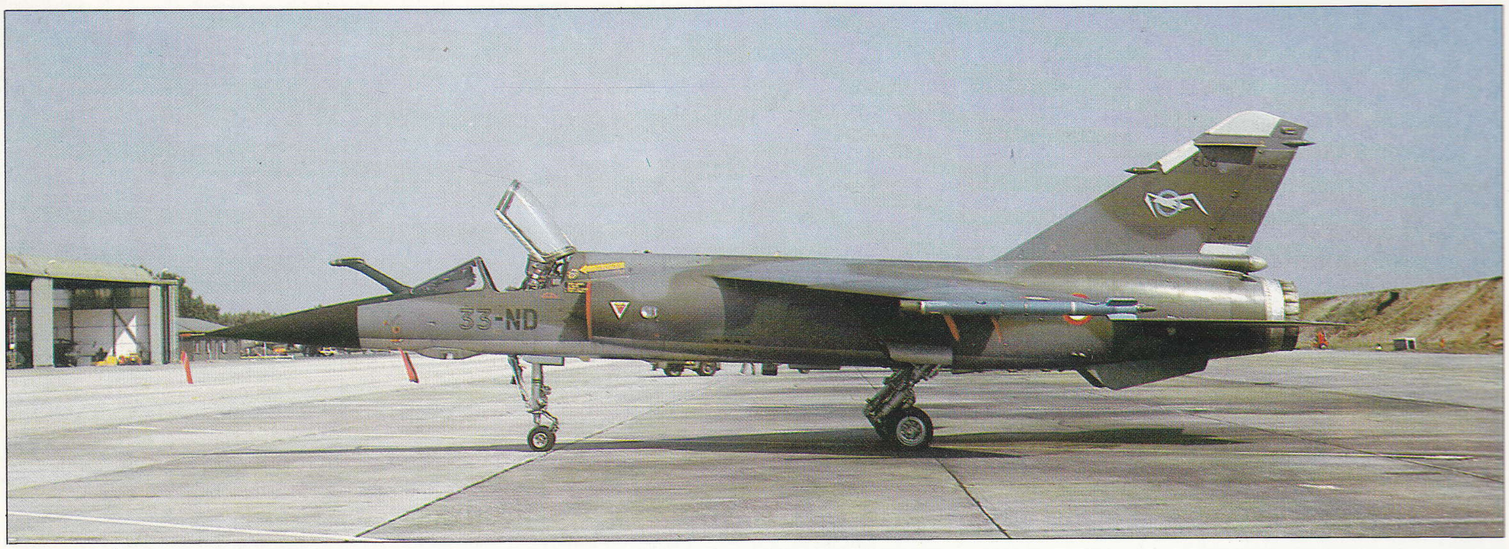
Specification

Mirage F.1CR

Type: single-seat tactical reconnaissance aircraft

Powerplant: one SNECMA Atar 9K-50 turbojet rated at 7200-kg (15,873-lb) afterburning thrust

Performance: maximum speed at sea level 1475 km/h (917 mph) or Mach 1.2;



maximum speed at altitude 2335 km/h (1,450 mph) or Mach 2.2; ferry range 3300 km (2,050 miles)
Weights: empty 7400 kg (16,314 lb); maximum take-off 16200 kg (35,715 lb)
Dimensions: span 8.40 m (27 ft 6¾ in); length 15.00 m (49 ft 2½ in); height 4.50 m (14 ft 9 in); wing area 25.00 m^2 (269.1 sq ft)

Now replacing the Mirage IIIs of the 33e Escadre at Strasbourg, the Mirage F.1CR can carry external reconnaissance pods as well as its internal cameras. Aircraft can carry Matra Magic air-to-air missiles for self-defence and this example is carrying practice missiles. Inflight-refuelling equipment is standard.

FRANCE/UK

SEPECAT Jaguar

Resulting from a collaborative venture between France and the United Kingdom, the **SEPECAT Jaguar** is primarily a single-seat strike/tactical support aircraft, and it is only the Royal Air Force which employs the type in the reconnaissance role, a task far removed from that originally envisaged when development work began in the mid-1960s.

At that time, the UK was searching for an advanced trainer aircraft whilst France was on the look-out for an inexpensive strike aircraft, and it seemed for a time that both of these requirements could be satisfied by a single design. In the event, the Jaguar metamorphosed into a somewhat more sophisticated machine than either nation originally planned, and there are significant differences between the French and British aircraft with regard to avionics fit.

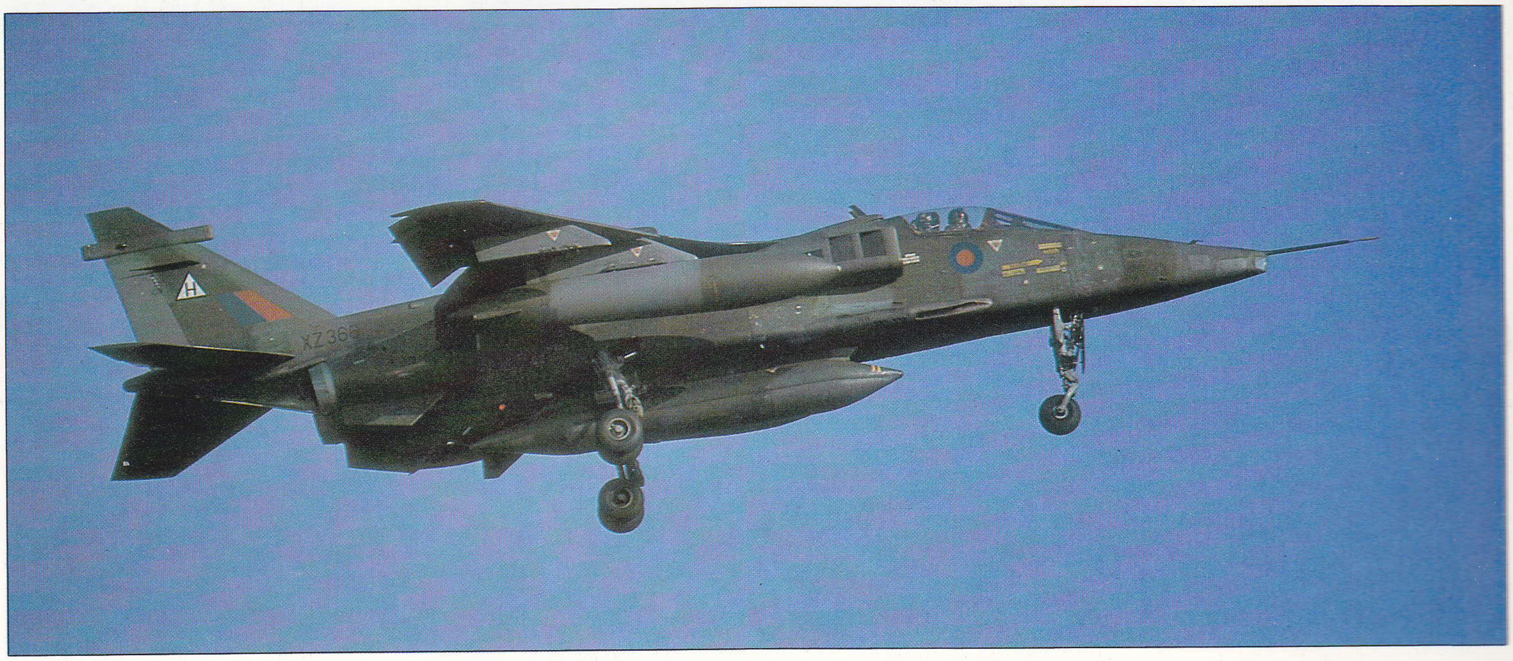
Tactical reconnaissance is undertaken by two RAF units (No. 2 Squadron at Laarbruch in West Germany and No. 41 Squadron at Coltishall in the UK), each equipped with **Jaguar GR.Mk 1** machines identical to those aircraft assigned to the six squadrons engaged in strike duties. For the units' designated reconnaissance role, however, their Jaguars each carry a large pod on the centreline stores station, containing cameras and infra-red linescan equipment. Reconnaissance cameras are located in a pair of rotating drums within the pod, swivelling to expose the camera ports during photography. Two side-mounted and one forward-looking camera are positioned in the forward drum whilst the second can contain a pair of oblique cameras for low-level work or a solitary vertical camera best suited for photography from medium altitudes. This combination offers quite comprehensive coverage, one particularly useful facility being a data conversion unit which automatically annotates the aircraft's position on the film, details of this being obtained from the onboard navigation computer. IR-linescan film is similarly marked.

In addition to serving with France and the United Kingdom, strike versions of the Jaguar have been supplied to India, Oman and Ecuador, the latest order coming from Nigeria.

Specification

Jaguar GR.Mk 1 .
Type: single-seat tactical reconnaissance/strike fighter
Powerplant: two Rolls-Royce/Turboméca Adour Mk 104 turbofans each rated at 3647-kg (8,040-lb) afterburning thrust
Performance: maximum speed at altitude 1700 km/h (1,055 mph) or Mach 1.6; ferry range 4205 km (2,614 miles)
Weights: empty about 7000 kg (15,432 lb); maximum take-off 15700 kg (34,612 lb)
Dimensions: span 8.69 m (28 ft 6 in); length 15.52 m (50 ft 11 in); height 4.89 m (16 ft 0½ in); wing area 24.18 m^2 (260.27 sq ft)

Jaguar GR.Mk 1s fly in the reconnaissance role with No. 2 Sqn in Germany, carrying a pod under the fuselage containing cameras and infra-red equipment. These form RAFG's tactical reconnaissance element and will eventually be replaced by Tornados.



UK

BAC Canberra

Although the basic design dates back to the late 1940s, the **BAC Canberra** is still in fairly widespread service, several specialized photographic-reconnaissance specimens being numbered amongst those aircraft that are still in use. In the United Kingdom a handful of **Canberra PR.Mk 9** aircraft equip No. 1 Photographic Reconnaissance Unit at Wyton but the main force of PR.Mk 9s are being completely rebuilt by Shorts (the original manufacturer) to carry CASTOR (Corps Airborne Stand-Off Radar), a giant SAR (Synthetic Aperture Radar) for surveillance over Germany from heights over 18.3 km (60,000 ft) exactly similar to that done by the TR-1A. India's air force is believed still to use a small number of **Canberra PR.Mk 57** aircraft on operational reconnaissance tasks. Finally, the Venezuelan air force still has a solitary example of the **Canberra PR.Mk 83** which serves alongside about a dozen Canberra B.Mk 82s and B(I).Mk 82s with Grupo de Bombardeo 13 at Barcelona.

Specification

Canberra PR.Mk 9

Type: two-seat tactical photographic reconnaissance aircraft

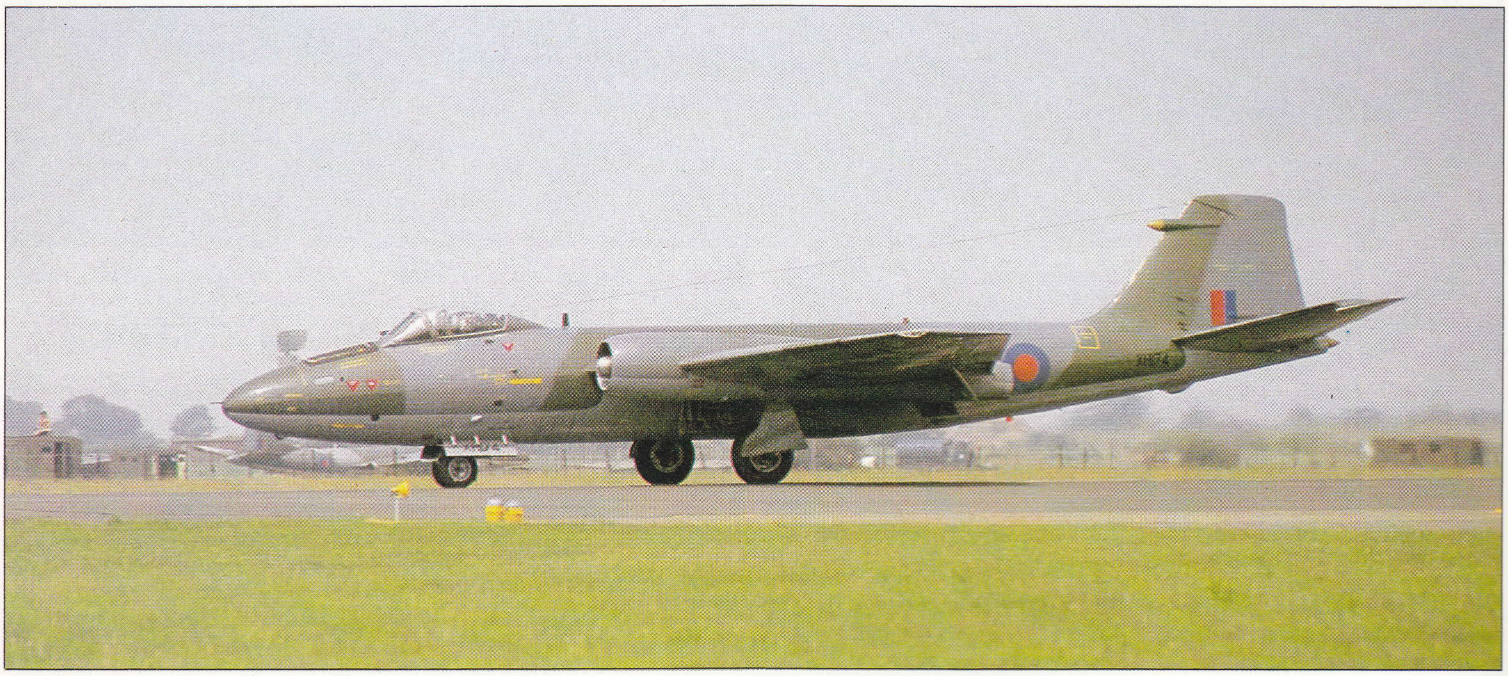
Powerplant: two Rolls-Royce Avon 206 turbojets each rated at 4559-kg (10,050-lb) thrust

Performance: maximum speed 998 km/h (620 mph) or Mach 0.94; service ceiling about 18290 m (60,000 ft); maximum range 7240 km (4,500 miles)

Weight: normal take-off 22680 kg (50,000 lb)

Dimensions: span 20.68 m (67 ft 10 in); length 20.32 m (66 ft 8 in); height 4.75 m (15 ft 7 in)

Alongside target tugs and ECM trainers, No. 1 Photographic Reconnaissance Unit operates Canberra PR.Mk 9 aircraft in a limited role.



ITALY

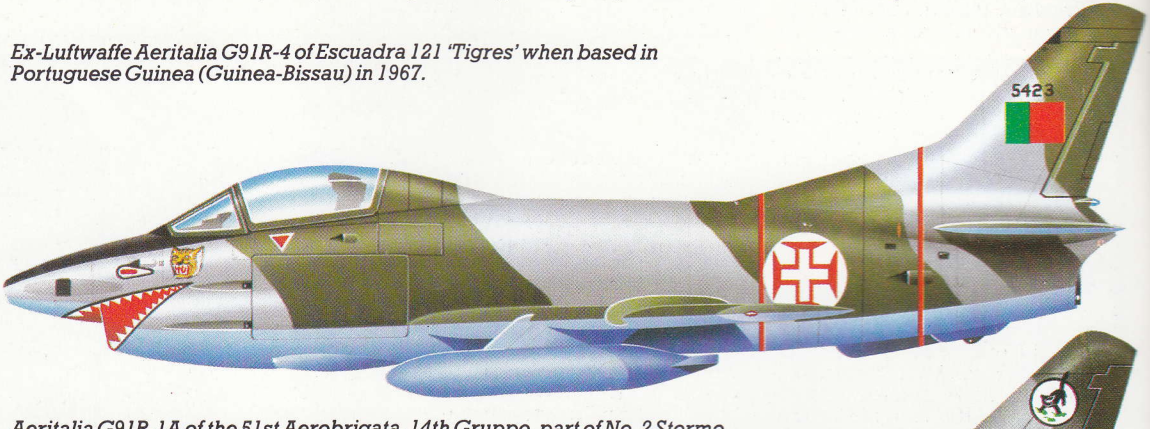
Aeritalia G91R

The winning contender of a NATO design contest to find a lightweight reconnaissance/strike fighter in the early 1950s, the **Aeritalia G91** flew for the first time on 9 August 1956 but failed to achieve widespread adoption by the nations which comprise the NATO alliance. Originally ordered for service with Greece, Turkey, Italy and West Germany, the type eventually achieved operational status only with the latter two nations, more than 700 being built. The majority were of **G91R** configuration featuring a modified nose installation containing three Vinten cameras for forward and lateral oblique photography.

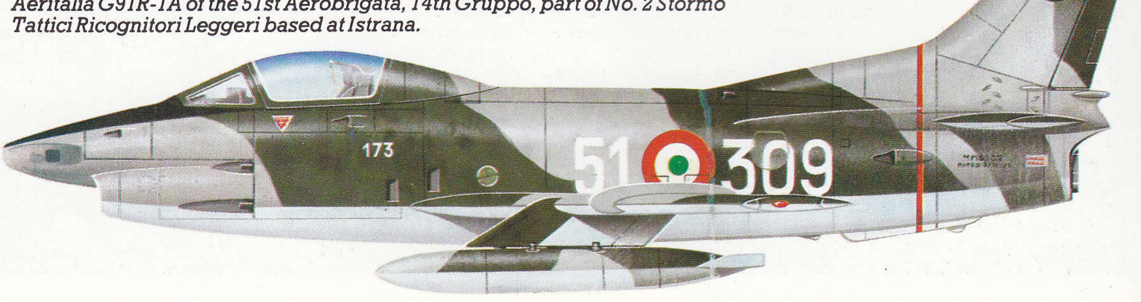
The initial production variant was the **G91R-1** which entered service with the Italian air force at the beginning of the 1960s, this air arm eventually acquiring over 100 similar aircraft. However, it was West Germany which proved to be the major customer, receiving a sizeable batch of Fiat-built **G91R-3** aircraft plus a substantial number built under licence by a consortium comprising Dornier, Messerschmitt and Heinkel. The first German-built example of the G91R-3 made its maiden flight from Oberpfaffenhofen during July 1961, and the type entered service with Aufklärungsgeschwader 53 at Leipheim during 1962.

In the event, Germany's Luftwaffe also operated some 50 or so **G91R-4** aircraft, originally being earmarked for equal distribution between Greece and Turkey, which eventually rejected them. After a fairly short career with the Luftwaffe, 40 of these aircraft were transferred to Portugal and the survivors remain in service today alongside a number of G91R-3s made redundant when the Luftwaffe re-equipped its light attack units with Dassault-Breguet/Dornier Alpha Jets in the late 1970s and early 1980s.

Italy also acquired a variant which was known as the **G91Y** and differed significantly, being larger all round and employing two General Electric J85-GE-13A afterburning turbojets in place of the G91R's single Orpheus. Like the G91R, this features a reconnaissance nose, the two prototypes being followed by 66 production specimens, most of which are still in service today. In addition, about 160



Ex-Luftwaffe Aeritalia G91R-4 of Escuadra 121 'Tigres' when based in Portuguese Guinea (Guinea-Bissau) in 1967.



Aeritalia G91R-1A of the 51st Aerobrigata, 14th Gruppo, part of No. 2 Stormo Tattici Ricognitori Leggeri based at Istrana.

32-10
32-16
32-13
32-7

examples of the two-seat G91T trainer variant were also completed and this has also seen service with Italy, Portugal and West Germany.

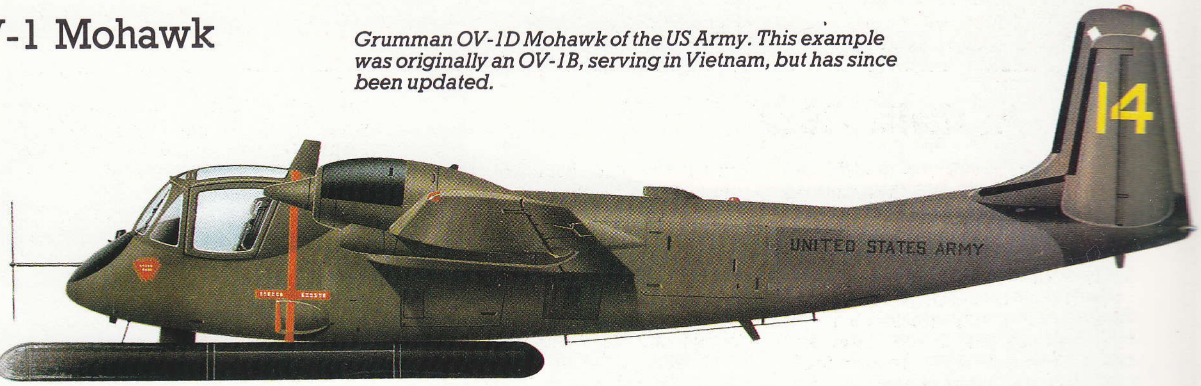
Specification
G91Y
Type: single-seat tactical reconnaissance/strike fighter
Powerplant: two General Electric J85-GE-13A turbojets each rated at 1851-kg (4,080-lb) afterburning thrust
Performance: maximum speed 1110 km/h (690 mph); service ceiling 12500 m (41,000 ft); combat radius at sea level 600 km (372 miles); ferry range 3500 km (2,175 miles)
Weights: empty 3900 kg (8,598 lb); maximum take-off 8700 kg (19,180 lb)
Dimensions: span 9.01 m (29 ft 6½ in); length 11.67 m (38 ft 3½ in); height 4.43 m (14 ft 6 in); wing area 16.42 m^2 (176.74 sq ft)

Aircraft of the Italian air force's 32° Stormo overfly Brindisi. These are G91Ys, differing from the earlier version by having two engines for greater payload and safety, and a redesigned nose.

USA

Grumman OV-1 Mohawk

Grumman OV-1D Mohawk of the US Army. This example was originally an OV-1B, serving in Vietnam, but has since been updated.



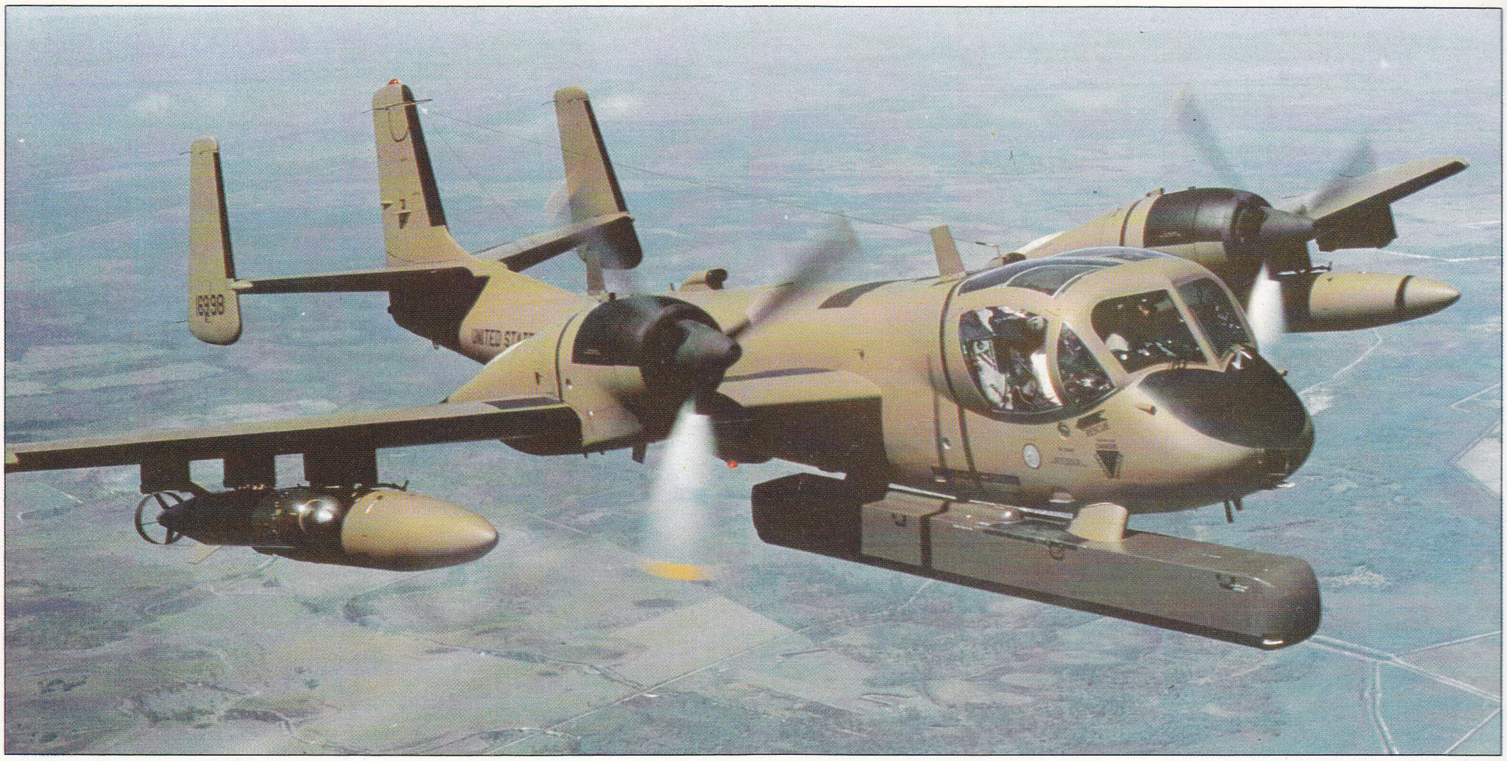
Intended primarily for battlefield reconnaissance duties, the somewhat bug-eyed **Grumman OV-1 Mohawk** dates back to the late 1950s, but despite its age and considerable vulnerability it remains in widespread service with the United States Army, which received close to 400 examples during the course of the 1960s.

Initial variants were reasonably unsophisticated but progressive modification efforts over the years have brought about a significant improvement in its sensor systems. The first production model to see service was the **OV-1A**, essentially intended to fulfil photographic reconnaissance duties by day or night, being fitted with cameras, flares and advanced navigation equipment. It was succeeded by the **OV-1B** which was the first model to incorporate SLAR (Side-Looking Airborne Radar), this AN/APS-94 equipment being housed in a prominent pod carried externally under the lower starboard forward fuselage. The next derivative was the **OV-1C**, which utilised the AN/AAS-24 infra-red sensor in place of the SLAR gear, while the final new-build member of the family was the **OV-1D**, basically a quick-change aircraft capable of operating with either infra-red or SLAR sensors. Deliveries of the OV-1D terminated in 1970, bringing total production to 375. Additional OV-1Ds were made available by the relatively simple expedient of converting most of the 100-plus OV-1Bs and OV-1Cs which remained.

More recently, a number of other derivatives have appeared, including the **RV-1D** and the **EV-1E**. The former version is a conversion of the OV-1B specifically intended for Elint (electronic intelligence) duty, the dozen or so aircraft known to exist being fitted with a multiplicity of passive receivers, analysers and recorders to gather unknown or 'hostile' signals. The EV-1E, again a rebuilt OV-1B, is fitted with AN/ALQ-133 'Quick Look II' surveillance radar, additional Elint equipment and electronic warfare pods. At least 16 conversions have been produced. Israel's air force has received two OV-1Ds, and continued updating effort should result in updated or converted OV-1Ds for various customers, including Pakistan and the US Army. The JOV-1B was an armed version used in Vietnam.

The Grumman OV-1D can carry the AN/AAS-24 infra-red surveillance system or, as here, the AN/APS-94 side-looking airborne radar (SLAR) package.

UNITED STATES ARMY



An excellent portrait of a JOV-1B Mohawk carrying the SLAR pod, long range fuel tanks and bombs. These aircraft saw much service in Vietnam and all have now been converted to OV-1D or RV-1D standard.

Specification
OV-1D

Type: two-seat battlefield surveillance/reconnaissance aircraft
Powerplant: two Avco Lycoming T53-L-701 turboprops each rated at 1,400 hp (1044 kW)
Performance: maximum speed 465 km/h (289 mph); range 1520 km (944 miles)
Weights: empty 5467 kg (12,053 lb); maximum take-off 8214 kg (18,109 lb)
Dimensions: span 14.63 m (48 ft 0 in); length (with SLAR) 13.69 m (44 ft 11 in); height 3.86 m (12 ft 8 in); wing area 30.66 m^2 (330 sq ft)

USA

Lockheed F-104 Starfighter

Winner of a previous so-called 'sale of the century' and used by several NATO air arms for many years, the **Lockheed F-104G** variant of the Starfighter is now fast disappearing from service within central Europe as more and more General Dynamics F-16 Fighting Falcons and Panavia Tornados become available.

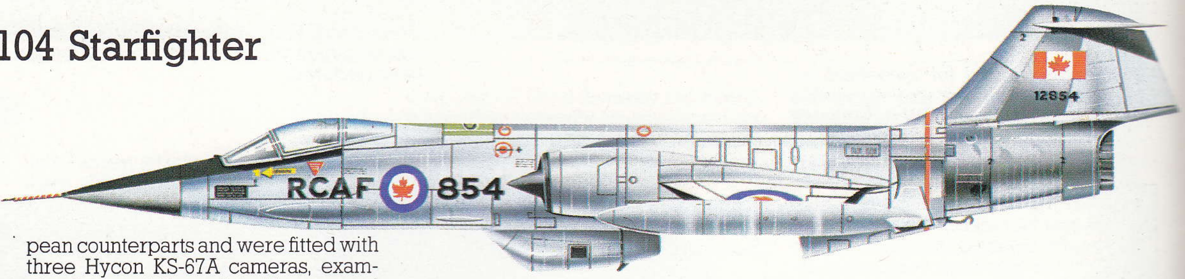
During its heyday, however, the Starfighter formed the backbone of the NATO alliance's air power and a number of reconnaissance-configured aircraft were produced, sensor packages varying considerably according to the specialized requirements of the parent air arm. The most widespread variant, and the one which remains in service today in modest numbers, was the **RF-104G**, which featured a belly fairing containing cameras, installation of these necessitating the removal of the M61 Vulcan rotary cannon armament. West Germany, Italy and the Netherlands all operated this variant of the Starfighter for a time, but today only Italy retains this type in its original configuration although the Netherlands does still use the standard F-104G for reconnaissance tasks, using the Orpheus pod to accomplish this mission. The German Luftwaffe and Marineflieger used the RTF-104G two-seater.

In addition to those aircraft manufactured in Europe during the early 1960s, the parent company also completed a number of RF-104Gs for export under the Military Assistance Program to friendly nations. These were essentially similar in appearance to their European counterparts and were fitted with three Hycon KS-67A cameras, examples being delivered to Norway and Taiwan, a small group still being in front-line service with the latter nation today whilst most of the Norwegian specimens have been passed on to Turkey.

Canada's **CF-104** was also originally engaged in reconnaissance duty, aircraft assigned to this task being fitted with a prominent belly-mounted pod containing a battery of Vinten cameras. This is no longer operational.

Specification
RF-104G

Type: single-seat all-weather tactical reconnaissance aircraft
Powerplant: one General Electric J79-GE-11A turbojet rated at 7167-kg (15,800-lb) afterburning thrust
Performance: maximum low level speed 1473 km/h (915 mph) or Mach 1.2; maximum stabilized speed at 12190 m (40,000 ft) 2124 km/h (1,320 mph) or Mach 2.0; tactical radius with external fuel 1110 km (690 miles)
Weights: empty 6486 kg (14,300 lb); maximum take-off 11352 kg (25,027 lb)
Dimensions: span 6.68 m (21 ft 11 in); length 16.69 m (54 ft 9 in); height 4.11 m (13 ft 6 in); wing area 18.22 m^2 (196.1 sq ft)

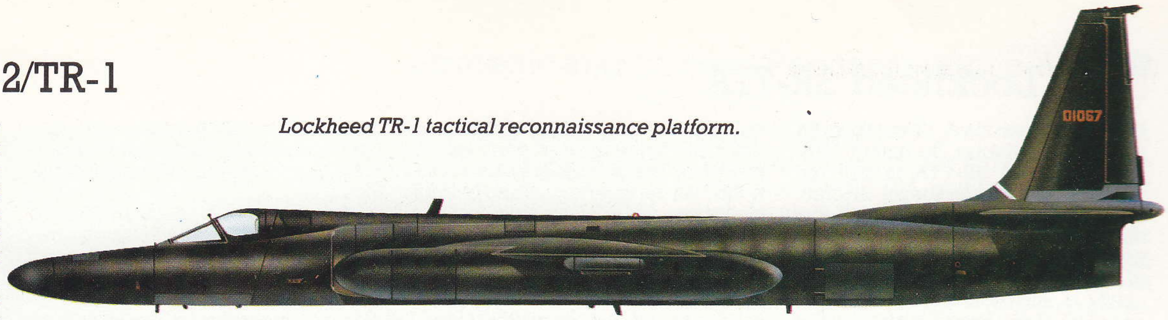


Lockheed CF-104G of No. 441 Sqn CAF at Marville, France, carrying the Vicom camera pod under the fuselage.

Although no longer used, the RF-104G Starfighter was an important reconnaissance type in the NATO inventory, carrying its cameras in the fuselage after the removal of the Vulcan cannon pod. The Dutch still fly F-104s in the recce role with Orpheus camera pods.

USA

Lockheed U-2/TR-1



Lockheed TR-1 tactical reconnaissance platform.

Colloquially known as 'the black lady of espionage', in a reference to earlier exploits on behalf of the Central Intelligence Agency, the **Lockheed U-2** family of reconnaissance aircraft is now somewhat overshadowed by this company's rather more spectacular SR-71 but it still has a valid role to play, this being reflected by the remarkable fact that, as the **TR-1**, it has recently been reinstated in production for the second time, a unique distinction indeed.

Conceived originally to meet a CIA requirement for an aircraft with the potential of operating at extreme altitude and first flown in the mid-1950s, the U-2's unique capabilities rendered it virtually immune from interception and made possible repeated overflights of the Soviet Union as part of the intelligence-gathering efforts of that era. The destruction of the aircraft being flown by Francis 'Gary' Powers in May 1960 brought an abrupt halt to this phase of activities, CIA attentions then focussing on the People's Republic of China which in the early 1960s was fast emerging as a major nuclear power.

Today, U-2 and TR-1 operations are usually conducted in what is best described as a 'permissive' environment on the friendly side of important frontiers. With the exception of a couple of aircraft assigned to NASA, none of the original production examples remain active, the principal model now used by Strategic Air Command being the **U-2R** which entered service in the late 1960s and which differs from its predecessors by virtue of greatly increased length and wing span. The U-2R is in the process of being joined by an increasing number of TR-1s, these externally being very similar although they are intended for tactical rather than strategic missions. Current USAF planning envisages basing about 18 **TR-1A** aircraft at Alconbury in the United Kingdom, these being tasked with surveillance of the battle area or potential battle area by day or night and in all kinds of weather. Flown for the first time in August 1981, the TR-1A will rely on a sophisticated array of electronic sensors to accomplish the reconnaissance mission. Currently carried is the UPD-X side-looking airborne radar and the Lockheed PLSS (Precision Location Strike System).

Two examples of a two-seat variant known as the **TR-1B** are assigned to training duties at Beale AFB, California, whilst a further machine, known as the **ER-2**, serves with NASA.

Specification

TR-1A

Type: single-seat all-weather tactical/ strategic reconnaissance aircraft

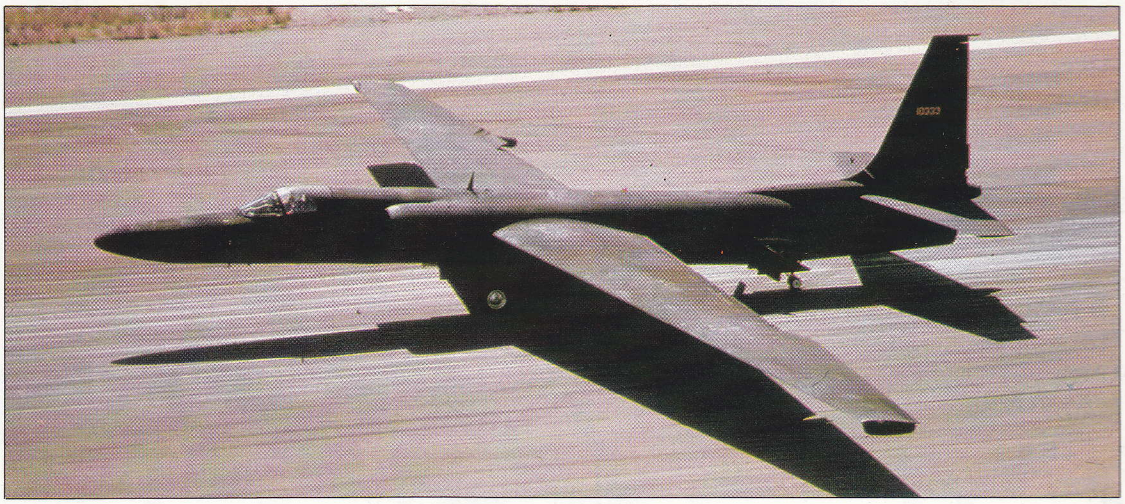
Powerplant: one Pratt & Whitney J75-PW-13B turbojet rated at 7711-kg (17,000-lb) thrust

Performance: estimated maximum cruise speed at over 21335 m (70,000 ft) 692 km/h (430 mph); operational ceiling estimated at 27430 m (90,000 ft); maximum range more than 4825 km (3,000 miles)

Weights: empty about 7258 kg (16,000 lb); maximum take-off 18144 kg (40,000 lb)

Dimensions: span 31.39 m (103 ft 0 in); length 19.20 m (63 ft 0 in); height 4.88 m (16 ft 0 in); wing area about 92.90 m^2 (1,000 sq ft)

Predecessor of the TR-1 was the U-2R, which in turn was a larger version of the earlier U-2. The utility 'U' designation veiled a more sinister role, and the U-2 aroused much controversy.



Below: The second test TR-1A aircraft seen over California, devoid of mission pods. All the early deliveries have come to Europe, notably the 17th Reconnaissance Wing at Alconbury.

USA

Lockheed SR-71A

Developed from the A-12 and flown for the first time during December 1964, the **Lockheed SR-71A** is still the world's fastest operational aircraft, approximately a dozen examples of this outstanding machine being active with the 9th Strategic Reconnaissance Wing at any given time. Possessing the ability to survey 260000 km^2 (100,000 sq miles) of the Earth's surface in just one hour, the SR-71A routinely cruises at Mach 3 at altitudes in excess of 24385 m (80,000 ft) during the course of its duties, and is able to gather a variety of data by virtue of highly classified but interchangeable photographic and electronic sensors which are installed to meet specific mission objectives.

Deliveries to Strategic Air Command began in January 1966, and it is believed that a total of 32 aircraft was built, this figure including two examples of the two-seat **SR-71B** plus a single **SR-71C**, the latter model also being a two-seater for pilot training, built of components taken from crashed aircraft and a structural test specimen.

Specific details of the work undertaken by the SR-71A remain shrouded in secrecy, but it is known that operations are routinely conducted from two forward operating locations by aircraft detached from the wing's headquarters at Beale AFB, California. The first of these, at Kadena in Okinawa, normally has three aircraft attached at any time, whilst Mildenhall in the United Kingdom is the location of the second SR-71 detachment which usually controls the activities of two aircraft. In addition, Beale serves as the centre for crew training and may well also support operational flights using inflight-refuelling to extend the range of the SR-71.

The rigours of high-speed flight at extreme altitude are such that the two crew members, comprising a pilot and a reconnaissance systems operator, both wear full pressure suits similar to those of astronauts and, indeed, selection procedures are identical to those originally used in choosing trainee astronauts.

Specification

SR-71A

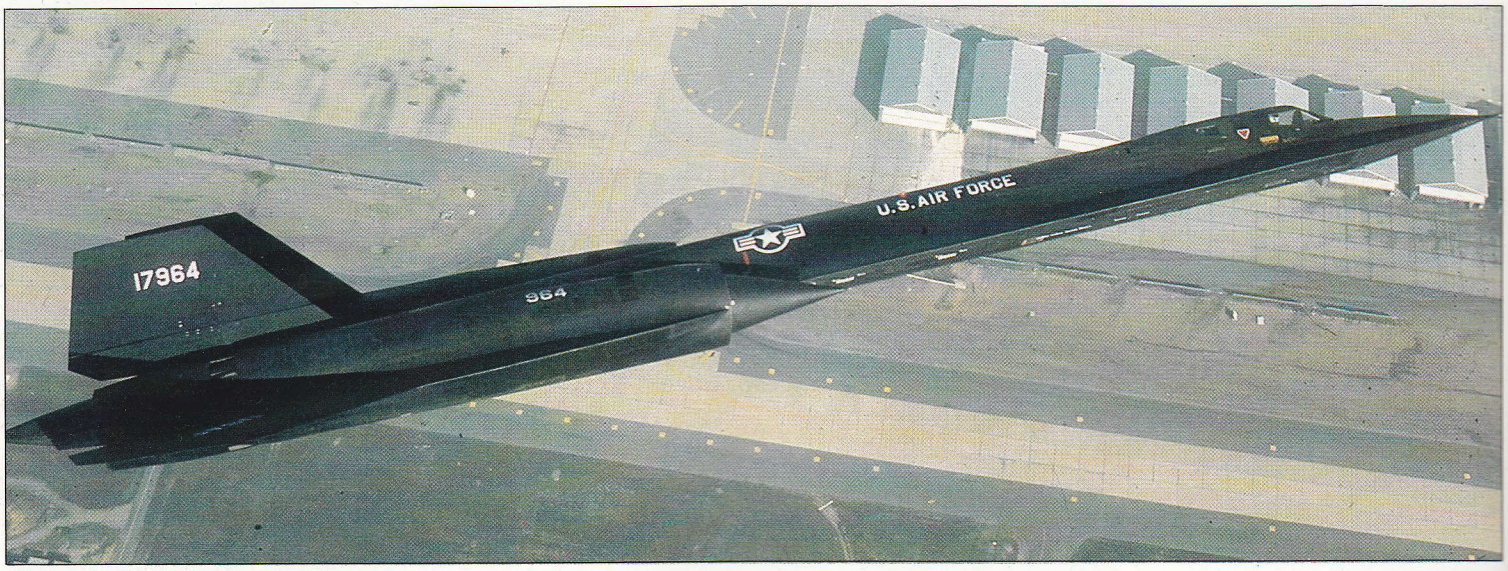
Type: two-seat all-weather strategic reconnaissance

Powerplant: two Pratt & Whitney J58 turbo-ramjet engines each rated at 14742-kg (32,500-lb) afterburning thrust

Performance: maximum speed at 24385 m (80,000 ft) 3661 km/h (2,275 mph) or Mach 3.35; operational ceiling 26060 m (85,500 ft); maximum unrefuelled range at Mach 3 5230 km (3,250 miles)

Weights: empty 27216 kg (60,000 lb); maximum take-off 78019 kg (172,000 lb)

Dimensions: span 16.94 m (55 ft 7 in); length 32.74 m (107 ft 5 in); height 5.64 m (18 ft 6 in); wing area 166.76 m^2 (1,795 sq ft)



Seen banking over its home base at Beale AFB, California, this SR-71A is from the 1st Strategic Reconnaissance Squadron, 9th SRW.

Lockheed SR-71 in Action

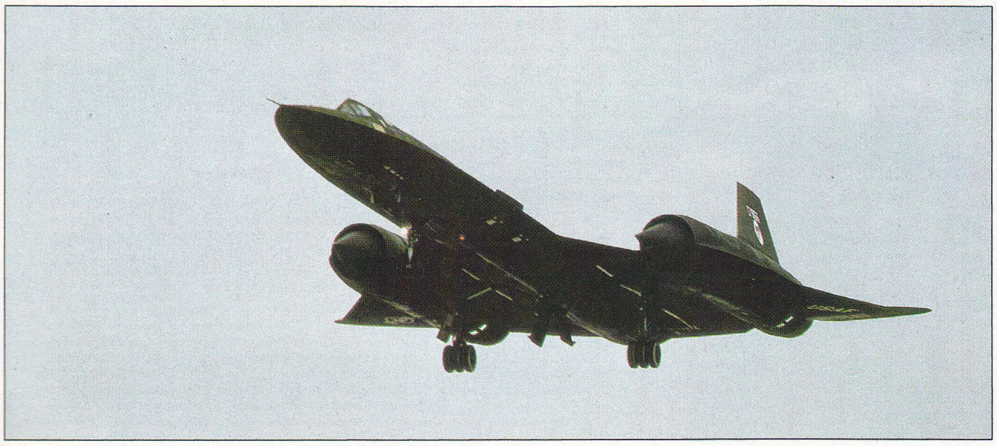
Vying for the title of the most remarkable aeroplane yet flown, the Lockheed SR-71 is even more amazing as it was designed with 1950s technology yet is still the fastest, highest-flying aircraft in the world. Although it became operational as long ago as 1967, there is still a virtual blackout on information about its deployment and equipment.

Almost certainly best known for its exploits in the record-breaking arena and perhaps most notably for the remarkable 1974 feat of crossing the Atlantic Ocean in just under 2 hours, the Lockheed SR-71 'Blackbird' is without doubt one of the most outstanding manifestations of the great progress made in aviation since the days of the Wright brothers' first tentative hops at Kitty Hawk less than 80 years ago. Capable of sustained Mach 3.0+ operation on the very fringes of space, the SR-71 must surely also represent the pinnacle of Clarence L. 'Kelly' Johnson's distinguished career, and yet it is interesting to note that, including all three members of the 'Blackbird' family, production of new airframes totalled just 49, a fiftieth hybrid machine being completed with parts from a wrecked YF-12A and an engineering mock-up. Of these 50 aircraft, only about a dozen or so SR-71s are at present active, but despite the fact that the basic design is now well over 20 years old it is still far and away the 'hottest' ship in the US Air Force's huge inventory.

Development of the 'Blackbird' family dates back to the spring of 1954 when Randolph S. Ray, a British engineer employed by the Summers Gyroscope Company in California, approached the USAF's Air Research and Development Command (ARDC) with a suggestion for a three-stage, propeller-turbine-powered aircraft using liquid hydrogen and liquid oxygen as fuel, this marking the start of close to 3½ years of quite intensive effort which at one time looked as if it would be translated into actual flying hardware. In the event, this project was abandoned in late 1957, being supplanted by a new programme which envisaged the construction of a high-speed, high-altitude, long-range reconnaissance aircraft of a much more conventional nature funded by and earmarked for service with the Central Intelligence Agency (CIA). In response to this initiative, a number of US companies submitted proposals for consideration, Lockheed's 'Oxcart' design eventually being adjudged most suitable, and this duly received the go-ahead in the autumn of 1959.

Construction of the prototype (60-5932) single-seat A-12, as the machine was officially known in company parlance, forged ahead at the 'Skunk Works', the virtually complete prototype being taken by road to the remote Groom Lake (alias 'Watertown Strip', alias 'The Ranch') flight test facility during January 1962 for final assembly and flight testing. It was from here that Lockheed's even more notorious U-2 had begun its flying career and, after being reassembled, the A-12 got airborne for its first official flight on 26 April 1962, this event being preceded by a totally unexpected 'hop' during the course of high-speed taxi trials two days earlier.

In the early days of the flight test effort, the first A-12 relied upon two Pratt & Whitney J75 turbojet engines for power, the same company's J58 turbo-ramjet engine not being installed until much later in the year. Almost inevitably, with such a sophisticated machine, the project suffered from many problems during the early stages of flight testing, these being experienced in virtually every area, but despite this the CIA apparently began to take



One of Lockheed's test aircraft seen landing at Palmdale. The badge carried on the tail is that of the 'Skunk Works' where the SR-71 was designed and developed.

formal delivery of its initial fleet of 10 aircraft (serial numbers 60-6924/6933) shortly before the end of 1962 and these were later joined by a second batch of five A-12s (60-6937/6941). Of these 15 machines, one (60-6927) was completed as a two-seater for training duties, this differing from its counterparts by virtue of having a second, raised, cockpit and featuring conventional J75 engines which bestowed a maximum speed of about Mach 1.2, well below that of the standard A-12 which was apparently capable of approximately 3860 km/h (2,400 mph) or Mach 3.6 at altitudes in the order of 28040 m (92,000 ft), figures which significantly exceeded those records established by the YF-12A at the beginning of May 1965. In addition, the last two production examples of the A-12 were configured to carry the little-known GTD-21B drone and these also featured a second crew station aft of the pilot's cockpit, this housing the Launch Control Officer. As far as is known the GTD-21B/A-12 pairing was not employed operationally but the drone may well have undertaken reconnaissance missions after launch from a specially configured Boeing B-52H Stratofortress.

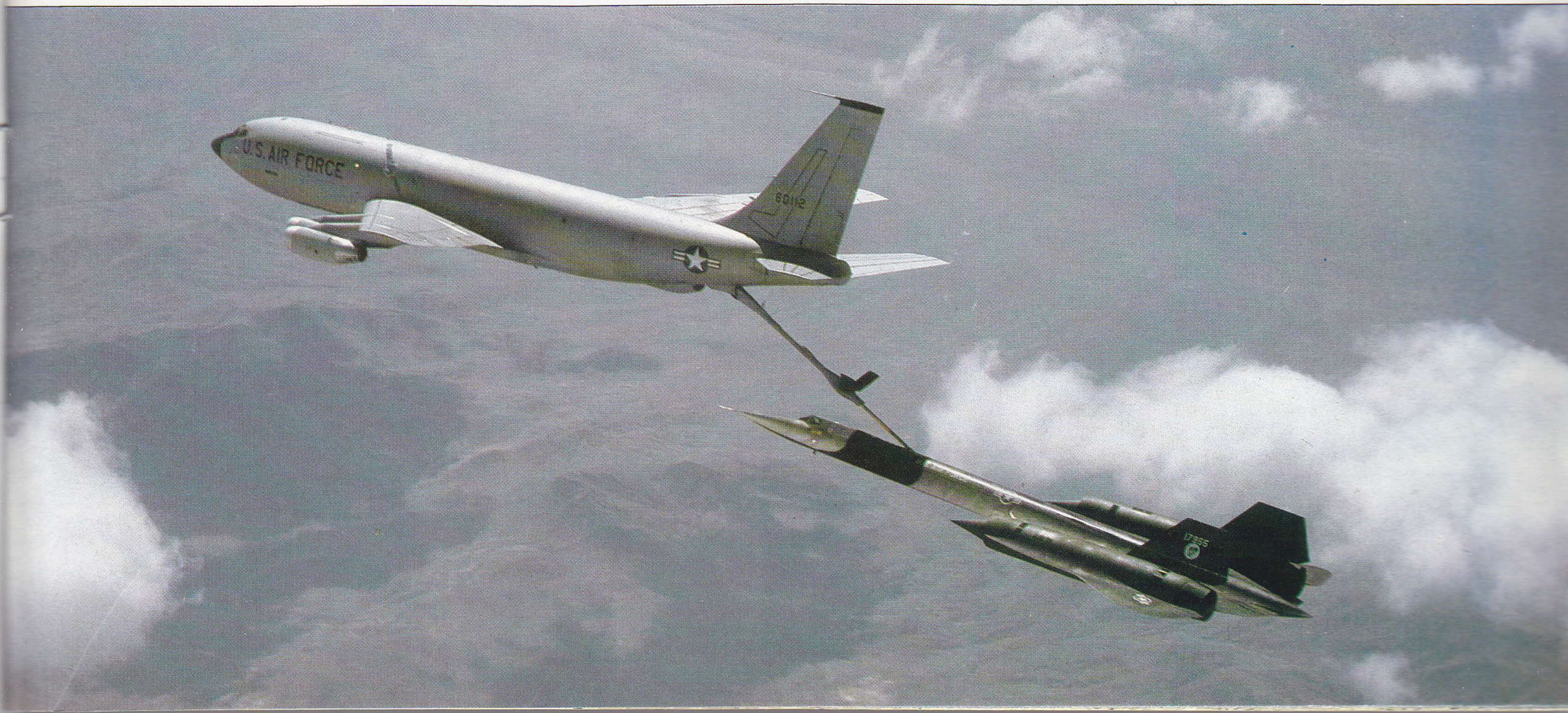
As far as operational employment is concerned, the CIA continues to maintain a tight-lipped silence about the A-12 but the type's great speed coupled with its capacity for in-flight-refuelling made range considerations virtually irrelevant, the major factor in mission scheduling almost certainly being one of crew fatigue. In view of this and the nonstop 24140-km (15,000-mile) missions accomplished by the later SR-71A it would seem reasonable to assume that intelligence-gathering was accomplished from Groom Lake until at least the summer of 1968, which most sources state as marking the cessation of A-12 activity. In addition, Kadena Air Base on the Pacific island of Okinawa has also been linked with A-12 operations as well as those of the SR-71A, and could well have served for some considerable time as a forward operating location for CIA intelligence gathering activities directed against the People's Republic of China and North Korea. Reliable reports attest that such activity ceased abruptly on 5 June 1968 following the loss of A-12 60-6932, apparently after take-off from Kadena. By then, of course, the SR-71A had attained full operational status and the latter type is believed to have assumed responsibility for A-12 missions at about this time. An interesting postscript is provided by the fact that eight of the 15 A-12s eventually appeared in open storage at Palmdale during October 1977 and all are still thought to be present there today. Quite where they had spent the intervening nine years remains a mystery, however.

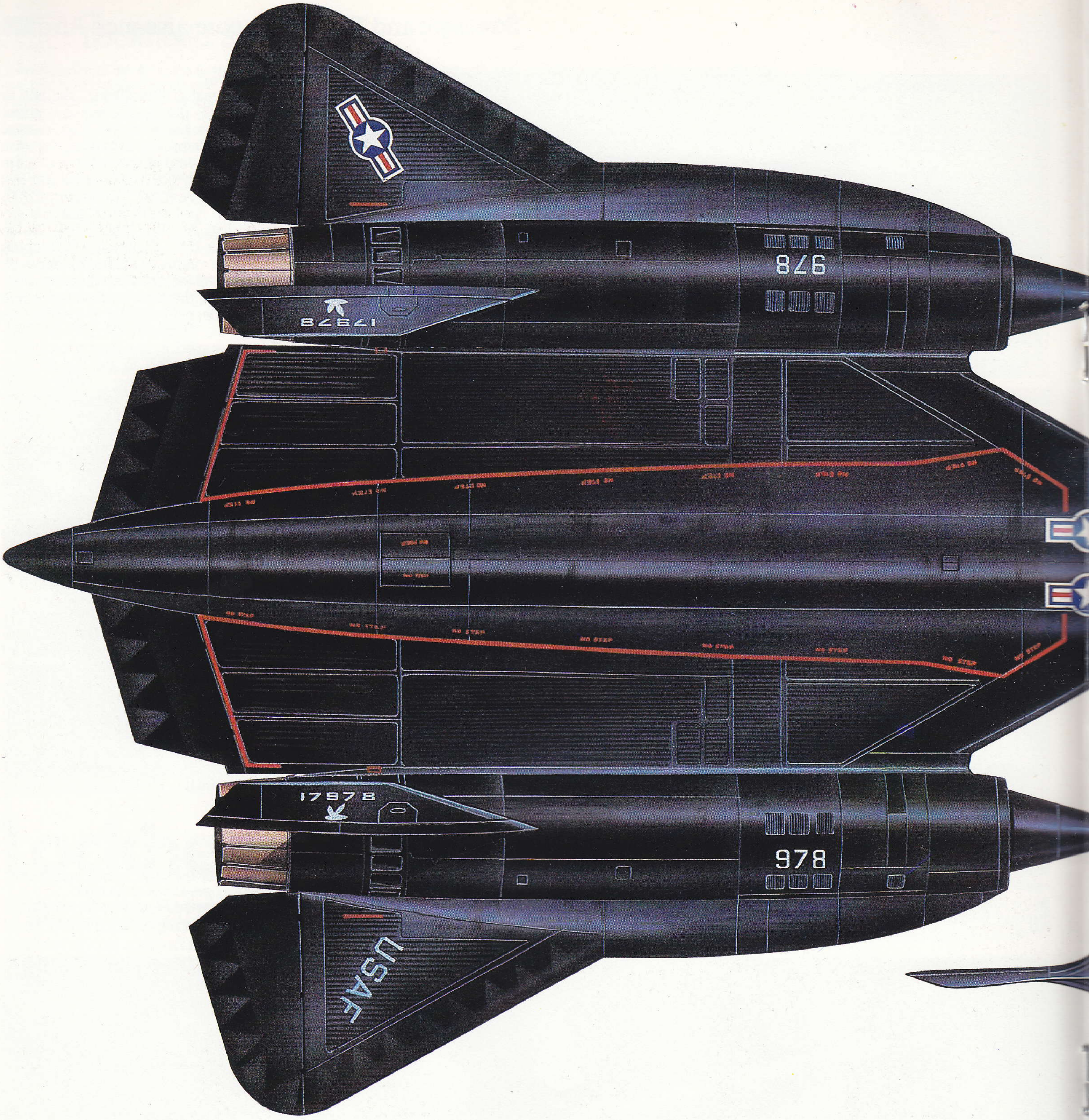
The second major 'Blackbird' variant to appear was the YF-12A, and it was this model which formed the basis of the Presidential announcement of February 1964 when Lyndon Johnson formally revealed the existence of the 'A-11 aircraft', adding that it was then under test as 'a long-range interceptor'. Three aircraft (60-6934/6936) of this type were built, the first example making its maiden flight from Groom Lake on 7 August 1963. Eventually to become the most publicly visible of all the 'Blackbirds', the three aircraft all featured significantly different nose contours, the forward fuselage chine having had to be redesigned to permit the installation of the Hughes AN/ASG-18 long-range radar required in the interceptor role. Armament was intended to be the Hughes AIM-47A air-to-air missile, four of which would have been housed internally, occupying space which was presumably given over to reconnaissance sensors and systems on the A-12.

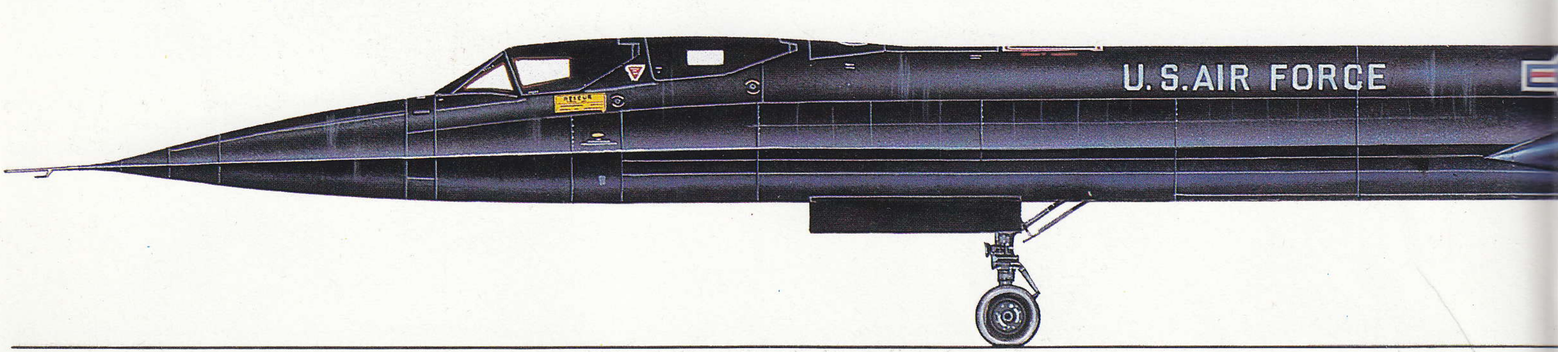
The YF-12A programme, seen as important in its own right, distracted attention from the more sinister A-12, the model which mounted an assault on several world records at the beginning of May 1965, capturing the headlines and setting new marks for sustained altitudes and speed with what appeared to be consummate ease. That the A-12 was able to exceed these figures handsomely was not brought to anyone's attention.

Subsequently, the YF-12As and a single YF-12C (itself simply the demilitarized second production SR-71A with the bogus serial number '06937') spent most of their flying careers at Edwards AFB, California, eventually being used for several years by NASA in a major research effort into high-speed flight. This came to an end during 1979, the sole surviving YF-12A (60-6935) being turned over to the USAF Museum at Wright-Patterson AFB, Ohio, in November while the YF-12C was apparently

JP-7, the fuel used by the SR-71, is so special due to its properties for operations at the high temperatures caused by Mach 3 cruise that the aircraft has its own fleet of tankers, designated KC-135Q.

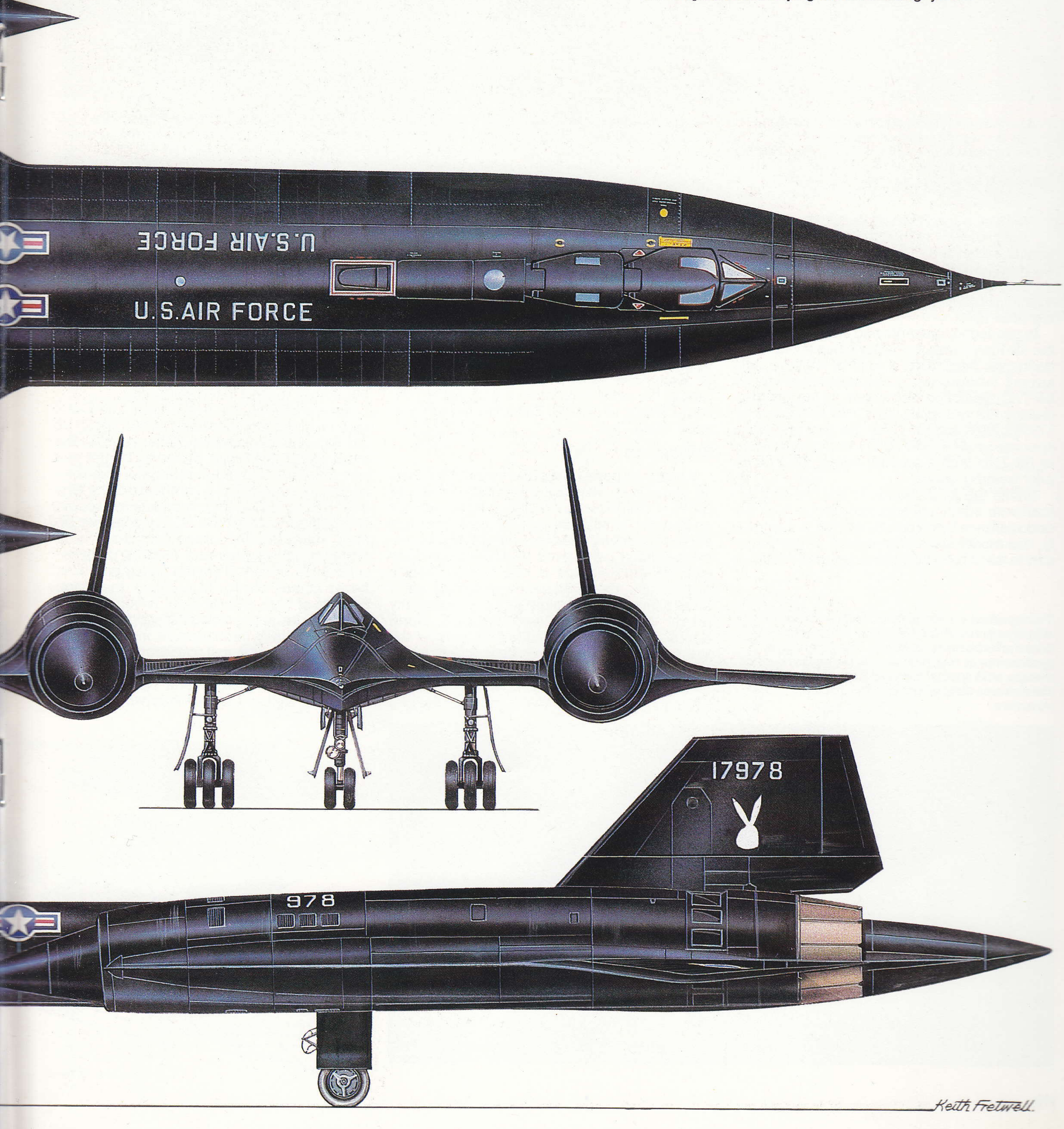


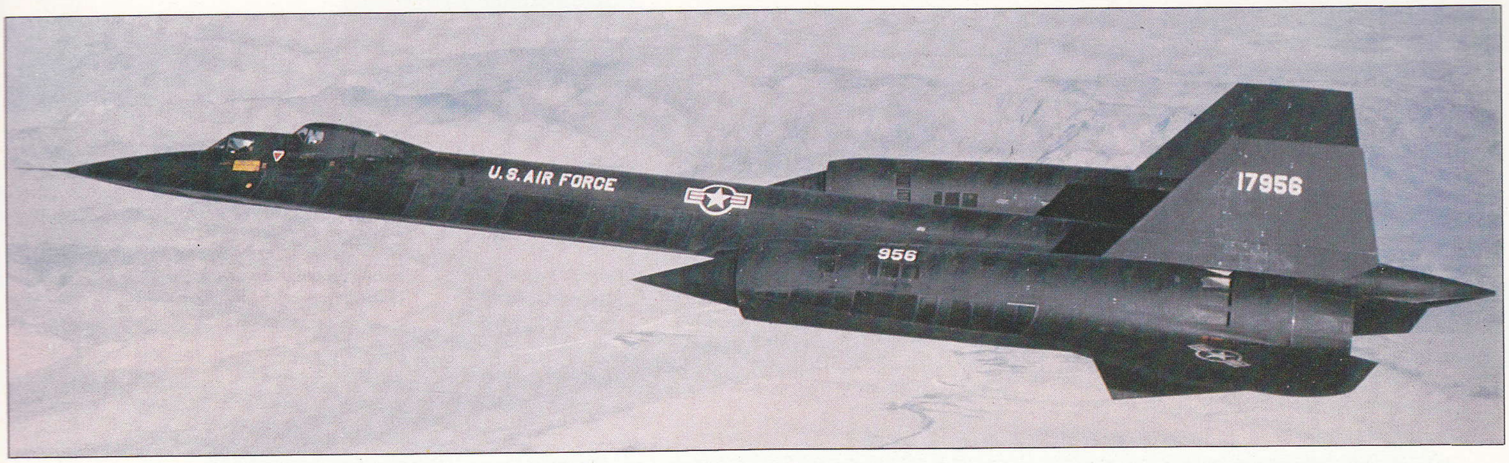

978
17978
NO STEP
17978
978
USAF


U.S. AIR FORCE

Lockheed SR-71

This illustration shows the true metallic blue colour of the SR-71, despite the unofficial name 'Blackbird'. The revolutionary design features of this aircraft are easily seen, including the chines along the fuselage, the cambered outer wings and the twin fins. At speed, the majority of the thrust comes from the airflow pressure distribution at the inlet to the engines. The window immediately aft of the cockpit is for the Northrop astro-inertial navigation system, and behind that is the receptacle for the flying-boom refuelling system.





This aircraft, 64-17956, was originally built as an SR-71A, but was later converted to an SR-71B trainer by the addition of a second cockpit. Two aircraft were converted, and a third built (SR-71C) after one of the earlier machines crashed.

placed in storage at Palmdale. Of the other two YF-12As, 60-6934 fell victim to a landing accident at Edwards at a fairly early stage, most of the rear fuselage later being used as a basis for the sole SR-71C, while 60-6936 was destroyed when it crashed on approach to Edwards during June 1971.

In production quantity and service duration, the SR-71 can reasonably lay claim to being the definitive 'Blackbird', a total of 31 new-build aircraft being constructed in addition to the SR-71C mentioned elsewhere. Of the total production, 29 examples (64-17950/17955 and 64-17958/17980) are SR-71As, the two remaining specimens (64-17956/17957) being completed as SR-71Bs with a second, raised, cockpit for pilot training duties.

Unlike the A-12, the SR-71 is a two-seat aircraft with additional accommodation for a Reconnaissance Systems Officer (RSO). Externally, this model also differed from its predecessors in that it has a fully extended chine which is much broader around the nose while the rear fuselage boat-tail was extended by some 1.83 m (6 ft) aft of the trailing edge to improve overall fineness ratio and provide additional fuel capacity.

An initial batch of six aircraft formed the subject of the first contract which was placed in December 1962, and the first example took to the air for its maiden flight from Palmdale almost exactly two years later, on 22 December 1964. Deliveries to the designated operating agency (Strategic Air Command) began on 7 January 1966, the first example assigned actually being the second SR-71B to be produced. SR-71As began to follow soon afterwards, the operating unit being the 4200th Strategic Wing at Beale AFB, California, redesignated during June of the same year when it adopted its present identity as the 9th Strategic Reconnaissance Wing.

Still secret

Attaining operational status in mid-1967, over 16 years later virtually everything about the SR-71's usage and mission-related sensor equipment is still the subject of a stringent security blanket, although the USAF has revealed that it 'can survey 100,000 square miles of the Earth's surface in one hour'. It seems certain that the intelligence-gathering effort entails unauthorized overflights of potentially hostile territory every now and then, North Korea being a likely candidate in view of the many protests emanating from this country. However, since much valuable data can be obtained without recourse to actual overflight, it seems probable that many missions are of a peripheral nature, the SR-71A operating in international air space at extreme altitude whilst going about its duties.

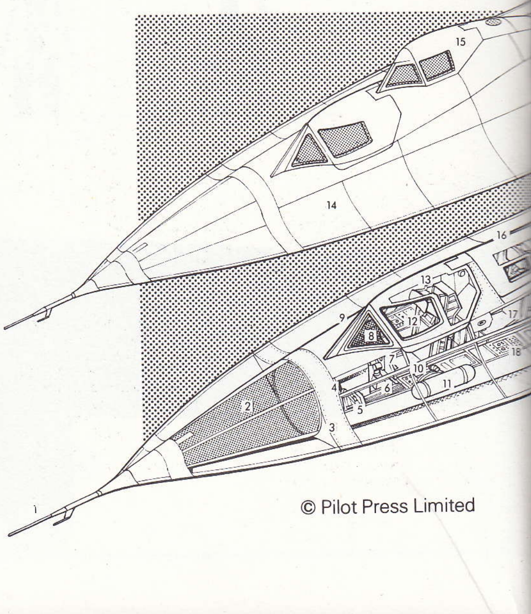
In view of the sensitive nature of the work performed, it is hardly surprising that the US Air Force has little to say about the SR-71 but it is common knowledge that, in addition to about half-a-dozen aircraft flying from the 9th SRW's headquarters at Beale, three more are active with Detachment One at Kadena, Okinawa, plus a further two with Detachment Four at Mildenhall in the United Kingdom.

Regardless of the equipment fitted, it is apparent that the 'Blackbird' is still highly regarded as an intelligence-gathering tool, clear evidence of this being provided by the massive expense incurred in supporting just a handful of aircraft. For a start there is the large fleet of Boeing KC-135Q Stratotankers (specially modified to carry the SR-71A's unique JP-7 fuel), whilst the undoubted complexity of the airframe, its engines and sensors dictates a substantial amount of contractor support which never comes cheap. In addition, the unique aspects of high-altitude flight require the services of a large physiological support division, further 9th SRW infrastructure including a reconnaissance technical squadron with the task of processing data, and an extensive training element which uses several Northrop T-38A Talons as well as the sole surviving SR-71B.

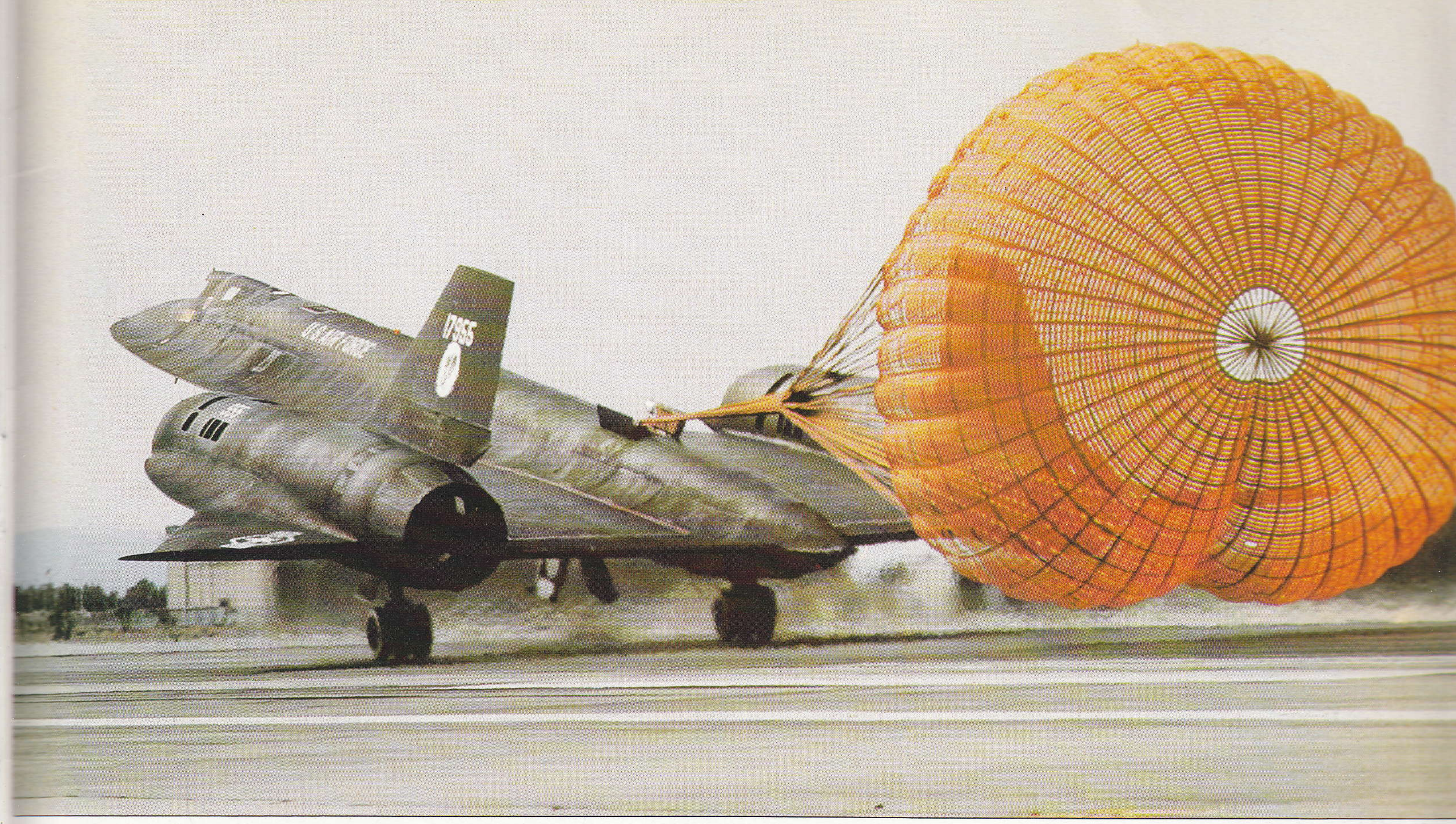
Right: An SR-71A after touching down; as the aircraft is designed for Mach 3 flight there is not much aerodynamic braking, and so a parachute is used to slow the plane down. Note the unusual three-wheel main landing gear.

Taking off on a mission from Beale AFB, an SR-71 displays its two Pratt & Whitney J58 continuous bleed afterburning turbojets. The propulsive system was as revolutionary as the aerodynamic design, with special fuel and engines to combat the extreme temperatures and stretching of the structure.

U.S AIR FORCE

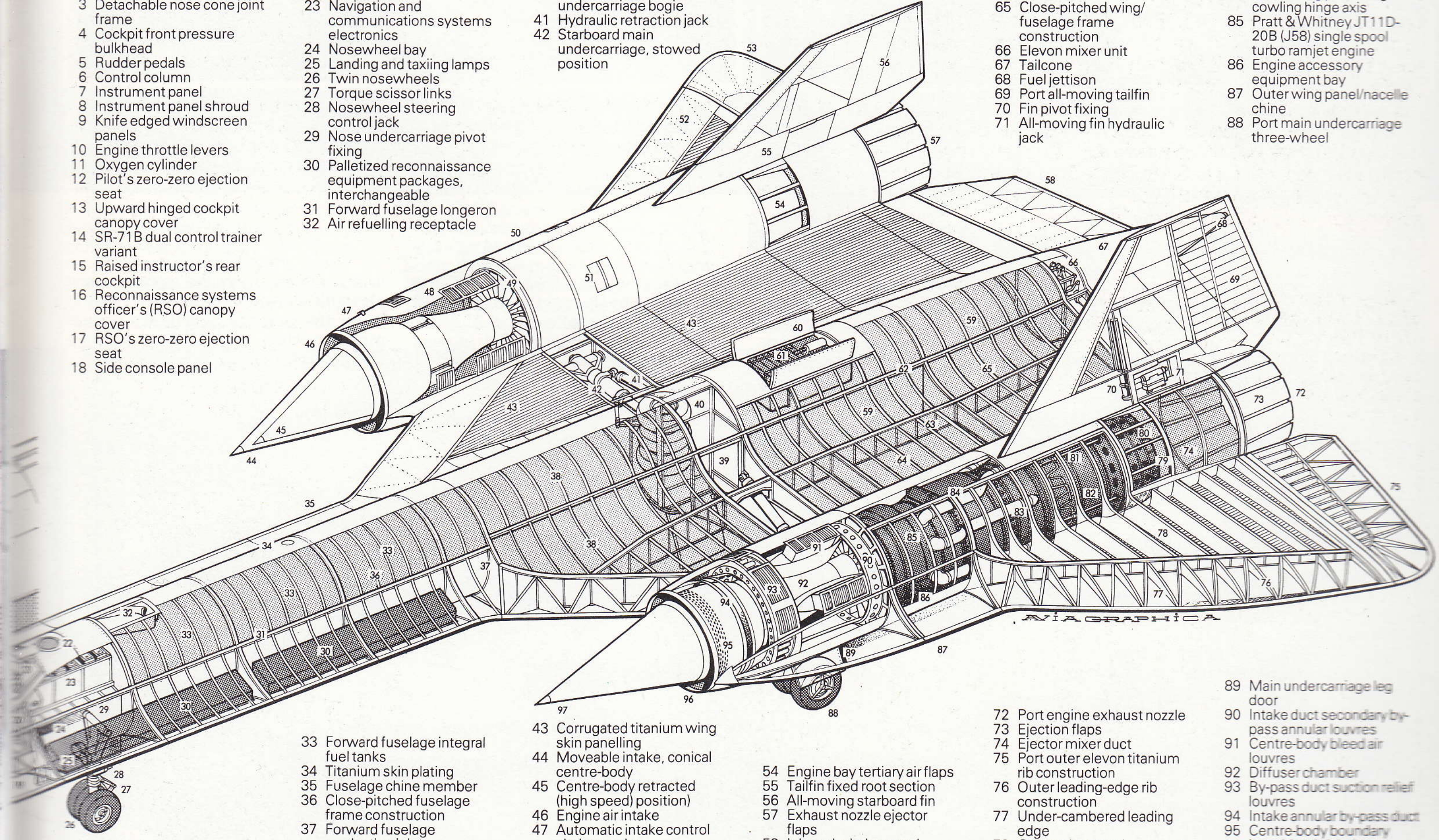


© Pilot Press Limited



Lockheed SR-71 'Blackbird' cutaway drawing key

1 Pitot tube
2 Nose mission equipment bay
3 Detachable nose cone joint frame
4 Cockpit front pressure bulkhead
5 Rudder pedals
6 Control column
7 Instrument panel
8 Instrument panel shroud
9 Knife edged windscreen panels
10 Engine throttle levers
11 Oxygen cylinder
12 Pilot's zero-zero ejection seat
13 Upward hinged cockpit canopy cover
14 SR-71B dual control trainer variant
15 Raised instructor's rear cockpit
16 Reconnaissance systems officer's (RSO) canopy cover
17 RSO's zero-zero ejection seat
18 Side console panel
19 Cockpit environmental system equipment bay
20 Rear pressure bulkhead
21 Canopy hinge joint
22 Astro-navigation star tracker
23 Navigation and communications systems electronics
24 Nosewheel bay
25 Landing and taxiing lamps
26 Twin nosewheels
27 Torque scissor links
28 Nosewheel steering control jack
29 Nose undercarriage pivot fixing
30 Palletized reconnaissance equipment packages, interchangeable
31 Forward fuselage longeron
32 Air refuelling receptacle
33 Forward fuselage integral fuel tanks
34 Titanium skin plating
35 Fuselage chine member
36 Close-pitched fuselage frame construction
37 Forward fuselage production joint
38 Blended wing/fuselage main integral fuel tanks (JP7 fuel)
39 Main undercarriage wheel bay
40 Three-wheel main undercarriage bogie
41 Hydraulic retraction jack
42 Starboard main undercarriage, stowed position
43 Corrugated titanium wing skin panelling
44 Moveable intake, conical centre-body
45 Centre-body retracted (high speed) position)
46 Engine air intake
47 Automatic intake control air data probe
48 Intake suction relief doors
49 Variable suction relief doors
50 Hinged engine cowling panel
51 By-pass blow-in doors
52 Starboard outer wing panel
53 Outboard, roll control, elevon
54 Engine bay tertiary air flaps
55 Tailfin fixed root section
56 All-moving starboard fin
57 Exhaust nozzle ejector flaps
58 Inboard, pitch control, elevon
59 Aft fuselage integral fuel tanks
60 Brake parachute doors
61 Ribbon parachute stowage
62 Rear fuselage longeron
63 Wing root rib
64 Inboard wing panel integral fuel tank
65 Close-pitched wing/fuselage frame construction
66 Elevon mixer unit
67 Tailcone
68 Fuel jettison
69 Port all-moving tailfin
70 Fin pivot fixing
71 All-moving fin hydraulic jack
72 Port engine exhaust nozzle
73 Ejection flaps
74 Ejector mixer duct
75 Port outer elevon titanium rib construction
76 Outer leading-edge rib construction
77 Under-cambered leading edge
78 Outer wing panel construction
79 Exhaust duct tertiary doors
80 Afterburner nozzle
81 Variable-area afterburner nozzle control jacks
82 Afterburner duct
83 Compressor bleed air by-pass ducts
84 Outer wing panel/engine cowling hinge axis
85 Pratt & Whitney JT11D-20B (J58) single spool turbo ramjet engine
86 Engine accessory equipment bay
87 Outer wing panel/nacelle chine
88 Port main undercarriage three-wheel
89 Main undercarriage leg door
90 Intake duct secondary by-pass annular louvres
91 Centre-body bleed air louvres
92 Diffuser chamber
93 By-pass duct suction relief louvres
94 Intake annular by-pass duct
95 Centre-body boundary layer bleed air holes
96 Port engine intake
97 Intake moveable centre body



Reconnaissance Sensors

Since World War 1, the art of aerial reconnaissance has advanced immensely through the introduction of, firstly, cameras and later electronic devices such as SLAR and infra-red linescan. Despite all this gadgetry, the pilot's eye can be just as important.

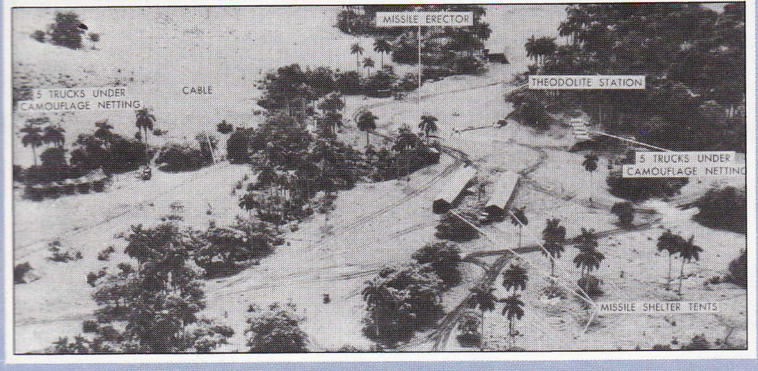
The earliest 'reconnaissance sensor' carried by an aircraft was the human pilot, usually with a notebook, and this is still a very important item, though pencil and paper have largely given way to a voice recorder. In 1914 the British Royal Flying Corps produced the first purpose-designed aerial camera, and cameras remain by far the most widely used reconnaissance sensors. While the optics, automaticity and general capability of the instrument have made great leaps in progress, even more important advances have been made with the film. It is central to today's surveillance by satellites and stratospheric aircraft that the film used should be so fine-grained that the image can be enlarged (reckoned on a basis of areas) hundreds or even thousands of times.

Thus a satellite can take a photograph of a man reading a newspaper so sharp that, when enlarged, it is possible to read not only the paper's headlines but also most of the text, and that from a distance of some 160 km (100 miles)! But most air reconnaissance is flown by high-speed jets at very low level, and here the problem is to avoid the slightest blurring caused by the speed at which the ground is rushing past the camera. Most cameras for low-level use have a V/h (aircraft velocity/height) adjustment which automatically moves the roll of film at exactly the same speed as the moving image focussed by the lens. Such cameras are mounted, either inside the fuselage or in an external streamlined pod, to look obliquely downwards either ahead or to each side. Almost all dedicated (used solely for that purpose) reconnaissance aircraft have a panoramic camera with three lenses, or a group of three separate cameras, to take simultaneous pictures vertically downwards and to left and right of track. From a height of 91 m (300 ft) the coverage typically extends 274 m (900 ft) to each side.

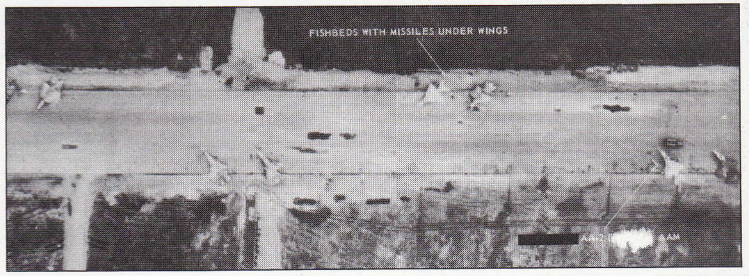
Of course, the angle at which the scene is viewed becomes ever further from vertical towards the edges of the picture, and special computers can today be provided to distort the photographs and make them appear as if the camera was vertically above every point! Even when the oblique viewpoint is retained, clever optics can be provided to take out various kinds of distortion, one purpose being to enable the photo interpreters to measure distances on the prints and quickly obtain the actual distances on the ground. There are many other things today's camera can do that only 20 years ago were difficult or impossible, one being to use special films which are sensitive to a wide range of electromagnetic wavelengths, not just visible light. Thus pictures taken by these cameras can defeat attempts at hiding or camouflaging objects, unless the enemy is equally clever and uses a similar wide spread of electromagnetic wavelengths.

The next part of the electromagnetic spectrum to visible light is called infra-red (IR), or heat radiation. IRLS (infra-red linescan) is a kind of TV system working at IR wavelengths. In effect it paints a thermal picture of the scene, colder items appearing darker and hotter items lighter. IRLS may not be colourful, but it not only shows what is present but can even show which boilers in a power station are working, which aircraft on an airfield has its engine(s) running, which aircraft has just landed from a mission, and where a truck or aircraft was recently parked even though it moved away several minutes ago.

TV itself is an important sensor, and a related device is the SLAR (sideways-looking airborne radar) which unlike optical cameras can produce pictures which cut out everything but the moving targets, such as an army truck. A further important feature of IRLS, TV and SLAR is that they all generate their pictures by using electrical signals, and it is possible not only to store the pictures on board the aircraft but also to transmit it by radio back to base, provided the latter is within line-of-sight range. At greater distances the information can be relayed by special high-flying communications aircraft or satellite. Thus, the people who need to have the reconnaissance information can receive it 'in real time', and do not have to wait for the aircraft to return from its sortie.


MISSILE ERECTOR
5 TRUCKS UNDER CAMOUFLAGE NETTING
CABLE
THEODOLITE STATION
5 TRUCKS UNDER CAMOUFLAGE NETTING
MISSILE SHELTER TENTS

An example of the sort of picture taken on a low-level mission is this photograph of a missile site on Cuba, taken from a USAF McDonnell RF-101 Voodoo. Although the picture dates from 1962, those of today would differ little.



Also from Cuba, this picture of MiG-21s parked on a runway was taken from high level. The clarity of the picture shows how useful basic black and white photography can be, and this still forms the basis of aerial reconnaissance.

USA

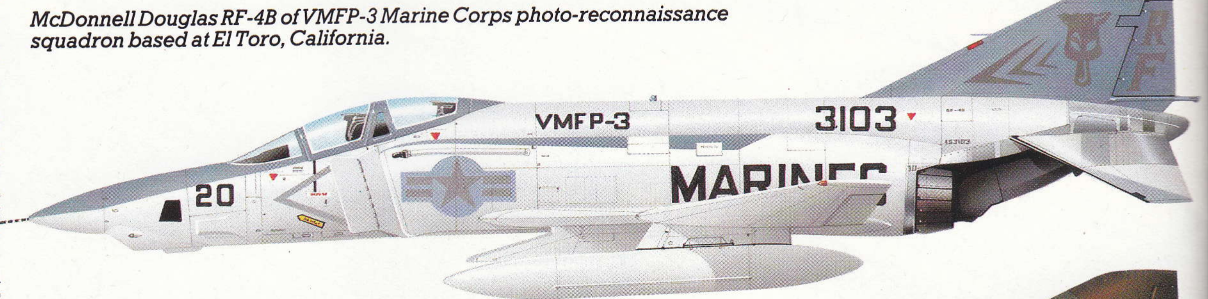
McDonnell Douglas RF-4 Phantom

Consideration was given to the possibility of developing a reconnaissance-configured variant of the **McDonnell Douglas F-4 Phantom** at an early stage in the type's operational career, but it was not until the US Air Force selected the basic fighter model to equip Tactical Air Command units that this proposal began to move ahead rapidly. Known by the designation **RF-4C**, the resulting aircraft flew in prototype form for the first time on 8 August 1963, this being the forerunner of over 500 similar machines, the last of which was formally handed over to the USAF over 10 years later, on 16 January 1974. A substantial number of these aircraft are still in regular and second-line service today.

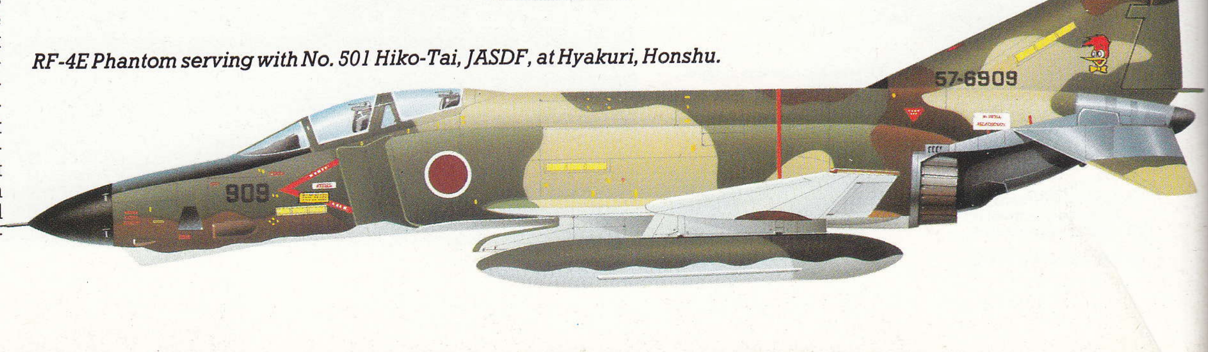
Easily recognized by the modified nose section which contains cameras and other reconnaissance sensors, the RF-4C entered operational service at Shaw AFB, South Carolina, in September 1964, although nearly a year passed before the first unit could be considered as combat ready. When that milestone was reached, overseas deployment followed quickly, aircraft being despatched to South East Asia for combat duty by the end of 1965, and the RF-4C remaining in use as the principal tactical reconnaissance tool for the remainder of the Vietnam War.

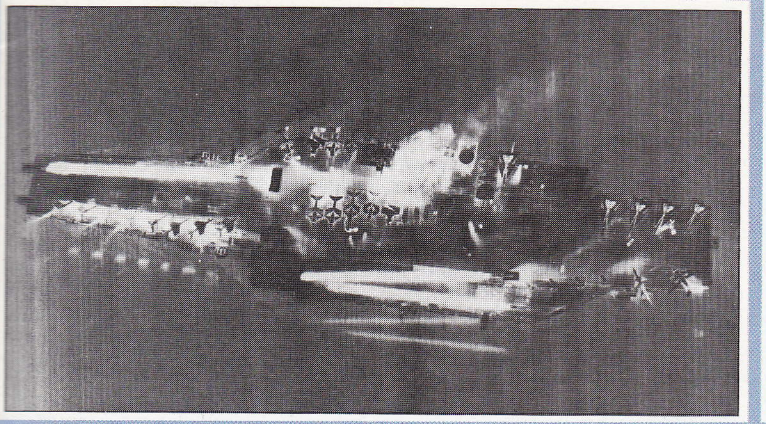
The second reconnaissance model to appear, rather confusingly designated **RF-4B**, was intended specifically for service with the US Marine Corps and this made its maiden flight on 12 March 1965 with deliveries to El Toro, California, following just two months later. A total of 46 RF-4Bs was supplied to this service, and the survivors are also still in front-line service, having been the subject of a fairly recent modification and life-extension programme.

McDonnell Douglas RF-4B of VMFP-3 Marine Corps photo-reconnaissance squadron based at El Toro, California.

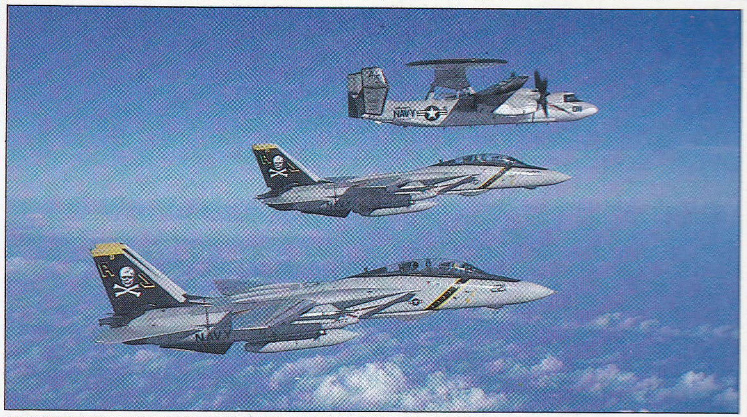


RF-4E Phantom serving with No. 501 Hiko-Tai, JASDF, at Hyakuri, Honshu.



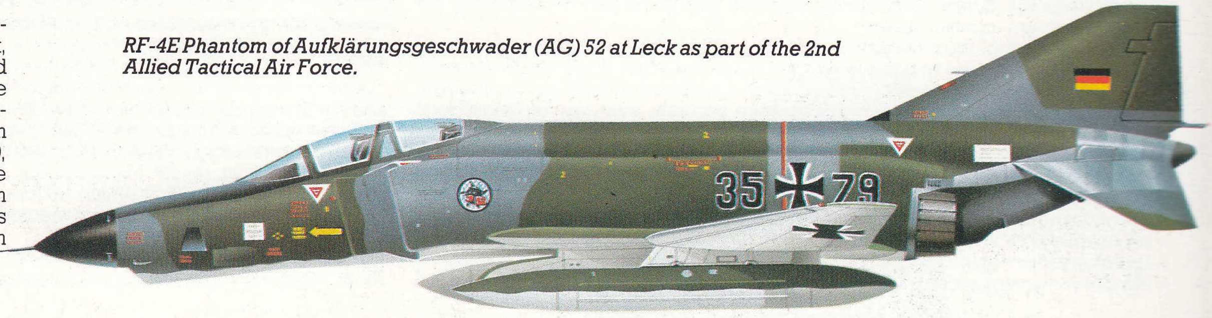


A demonstration infra-red image of the American carrier USS Ranger showing the heat sources (funnel, aircraft engines etc) which this form of sensor picks up. This can be extremely useful in detecting hidden and camouflaged objects which a light camera would not pick up.



Many aircraft are fitted with cameras (usually in pods) to serve in a secondary reconnaissance role. The Grumman F-14 Tomcat carries the Tactical Air Reconnaissance Pod System (TARPS) under the fuselage, employing two light cameras and an infra-red sensor.

As well as producing reconnaissance Phantoms for the home market, McDonnell Douglas also developed the **RF-4E** variant, initially in response to a Luftwaffe requirement for 88 aircraft to undertake this mission. Flown for the first time on 15 September 1970, the RF-4E subsequently also joined the air arms of Greece, Iran, Israel, Japan and Turkey, just over 160 aircraft of this type being built before production ceased.



RF-4E Phantom of Aufklärungsgeschwader (AG) 52 at Leck as part of the 2nd Allied Tactical Air Force.

Specification

RF-4C Phantom II

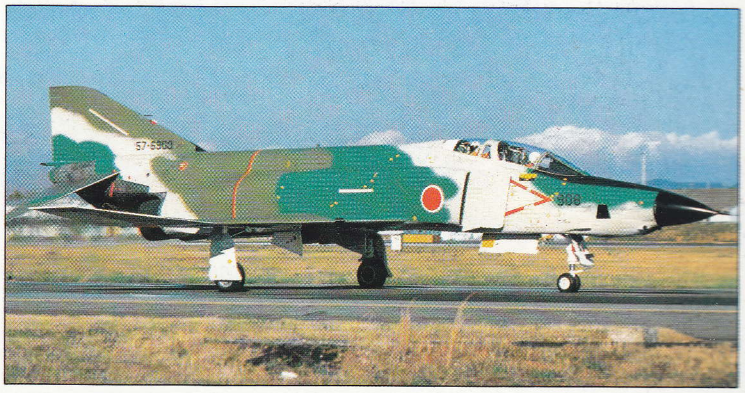
Type: two-seat all-weather tactical reconnaissance aircraft

Powerplant: two General Electric J79-GE-15 turbojets each rated at 7711-kg (17,000-lb) afterburning thrust

Performance: maximum speed at low level 1464 km/h (910 mph) or Mach 1.19; maximum speed at altitude 2414 km/h (1,500 mph) or Mach 2.27; ferry range 3700 km (2,300 miles)

Weights: empty 13290 kg (29,300 lb); maximum take-off 26309 kg (58,000 lb)

Dimensions: span 11.71 m (38 ft 5 in); length 19.20 m (63 ft 0 in); height 5.02 m (16 ft 5½ in); wing area 49.24 m^2 (530 sq ft)



Right: Wearing the camouflage applied to all JASDF tactical aircraft, this RF-4EJ is one of the multi-sensor reconnaissance aircraft supplied to Japan by McDonnell Douglas from St Louis. The Japanese fighter versions were built under licence in Japan. The window for the sideways-looking camera is clearly visible.

Below: Seen against an impressive backdrop of the Nevada mountains and assorted A-7s and F-16s, these two RF-4Cs from the USAF's 363rd Tactical Reconnaissance Wing leave Nellis AFB for a mission during the 1981 'Red Flag' exercises.

Reconnaissance over the Battlefield

Whilst the SR-71 and U-2 have captured the public imagination, the majority of reconnaissance aircraft are involved in the tactical arena: flying low and fast over the battlefields and installations, providing visible pictures of the immediate weapons of war, and following up strikes to assess whether those weapons are still a threat.

Now that the military forces of the various members of the NATO alliance are shrinking, it is clearly vital to ensure that the best possible use is made of those resources that remain available. Consequently, the disposition of such assets assumes ever greater importance in times of war and it is therefore equally important to ensure that accurate and timely intelligence relating to enemy troop concentrations, orders-of-battle and intentions is readily available to the commander on the battlefield.

Such material may be obtained in a number of quite disparate ways (the agent operating alone behind enemy lines is one example of the intelligence-gathering effort, even though his contribution may be small because of the difficulty in moving freely around the countryside) but no matter what its origins, if the intelligence is accurate it will almost certainly play some part in influencing the course that any conflict takes.

Another form of the intelligence-gathering effort is aerial reconnaissance and it is probably fair to say that this is now the most important single tool available to the battlefield commander, for the results of a successful sortie can be disseminated rapidly, and it also permits a far more accurate overview of the general situation.

As the accompanying survey of aircraft indicates, aerial reconnaissance activity falls into two main spheres (strategic and tactical), and it is the latter which is of greater value in times of battle since it is closely tailored to meet the immediate needs of the forces engaged in war. This is not to say that strategic reconnaissance is of no value in such situations, but since it is generally directed towards obtaining information closely allied to the long-term view, it only rarely results in the acquisition of data of immediate value. Equally significant, most of the aircraft types currently engaged in strategic reconnaissance are large and relatively unwieldy: exposing them to the risks likely to be encountered over a fluid battlefield would be foolhardy and expensive since they would be unlikely to survive for long without the protection of fighter aircraft better employed elsewhere.

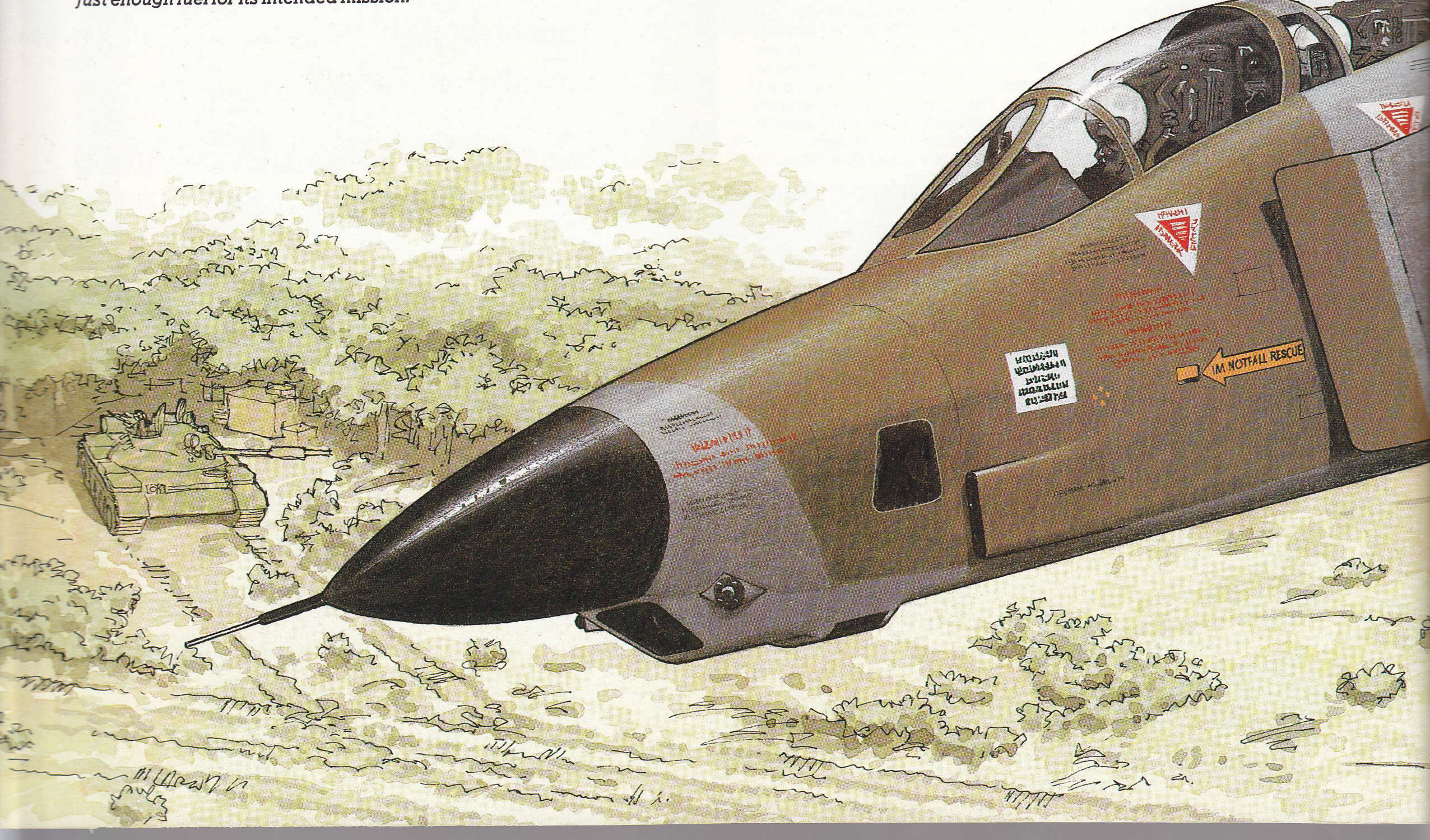
Tactical reconnaissance types, on the other hand, generally take the form of a modified fighter or attack aircraft and are thus far better equipped to survive in high-threat situations similar to those which would almost certainly prevail. Many, in addition, retain secondary strike/attack duty. Some types, such as the US Air Force's McDonnell Douglas RF-4C Phantom, are purpose-built to perform the aerial reconnaissance task whilst others (the Royal Air Force's SEPECAT Jaguar is one which springs readily to mind) merely use an external pod housing a variety of cameras and sensors; but despite this different approach both are highly efficient.

Despite the fact that it was first employed for reconnaissance purposes during the course of World War I, the camera is still the basic tool today, although the types now used are far removed from the unsophisticated devices of 65 years ago. For low-level, high-speed, work cameras with lenses of a short focal length are used since these result in the widest field of view and they are often arranged in fans so as to provide horizon-to-horizon coverage on a single pass over the target area; conversely, medium- and high-altitude photography demands long focal length lenses which result in good image size. It should also be borne in mind that most strike aircraft now also carry BDA (Bomb Damage Assessment) cameras which photograph weapon impact points to assist in the post-strike study of a particular raid. Although not exactly up to the standards of purpose-built reconnaissance cameras, the pictures obtained by these can also reveal hitherto undetected and unsuspected targets.

Heat photographs

Various types of film, each offering different qualities, are also used but black and white still predominates. Colour film, however, can be of great value since it provides greater contrast and often permits photo-interpreters to find camouflaged targets which would not show up on black and white, while colour infra-red film can reveal the presence of freshly-cut foliage (still a favourite method of camouflaging) which takes on a different hue due to the loss of chlorophyll. Photoflash cartridges ejected in flight normally provide illumination for night photography.

Another important sensor is infra-red linescan which is fitted to both the RF-4C Phantom and the reconnaissance-configured Jaguar. Essentially, this



The classic tactical reconnaissance type is the McDonnell Douglas Phantom, here exemplified by an RF-4E of Aufklärungsgeschwader (reconnaissance wing) 51 of the Luftwaffe. The usual battery of cameras is carried in the nose, looking forwards, sideways and immediately downwards. The aeroplane is also equipped with infra-red linescan, which can pinpoint abnormal heat sources such as tank or truck engines, concentrations of troops, and fires. The aircraft is capable of high speed (approximately Mach 1.2 at low level), and in order to achieve this is stripped of any unnecessary pylons and attachments, carrying just enough fuel for its intended mission.

produces a heat-picture of the terrain being examined, and it is particularly valuable in penetrating camouflage and revealing the presence of 'hot spots' such as camp fires, trucks, troop concentrations or, indeed, anything that emits a measurable amount of heat. Such is the sensitivity of this equipment that it can often indicate the recent presence of aircraft on a dispersal, being able to detect the heat 'footprint' left after departure. In addition there is radar, another useful tool, and many of the aircraft engaged in the reconnaissance mission are now fitted with SLAR (Side-Looking Airborne Radar) equipment which possesses the ability to observe and track moving targets by employing the Doppler shift technique, whilst the installation of data-link apparatus enables near real-time raw radar imagery to be relayed to ground stations in the battle area, thus permitting more rapid dissemination of data amongst those who need it most. Finally, there is the trusty 'Mk 1 Eyeball' which is still a most important sensor even in this era of super-sophistication, and there is little doubt that visual sightings by trained observers such as forward air controllers will play a significant part in any future conflict.

Data delay

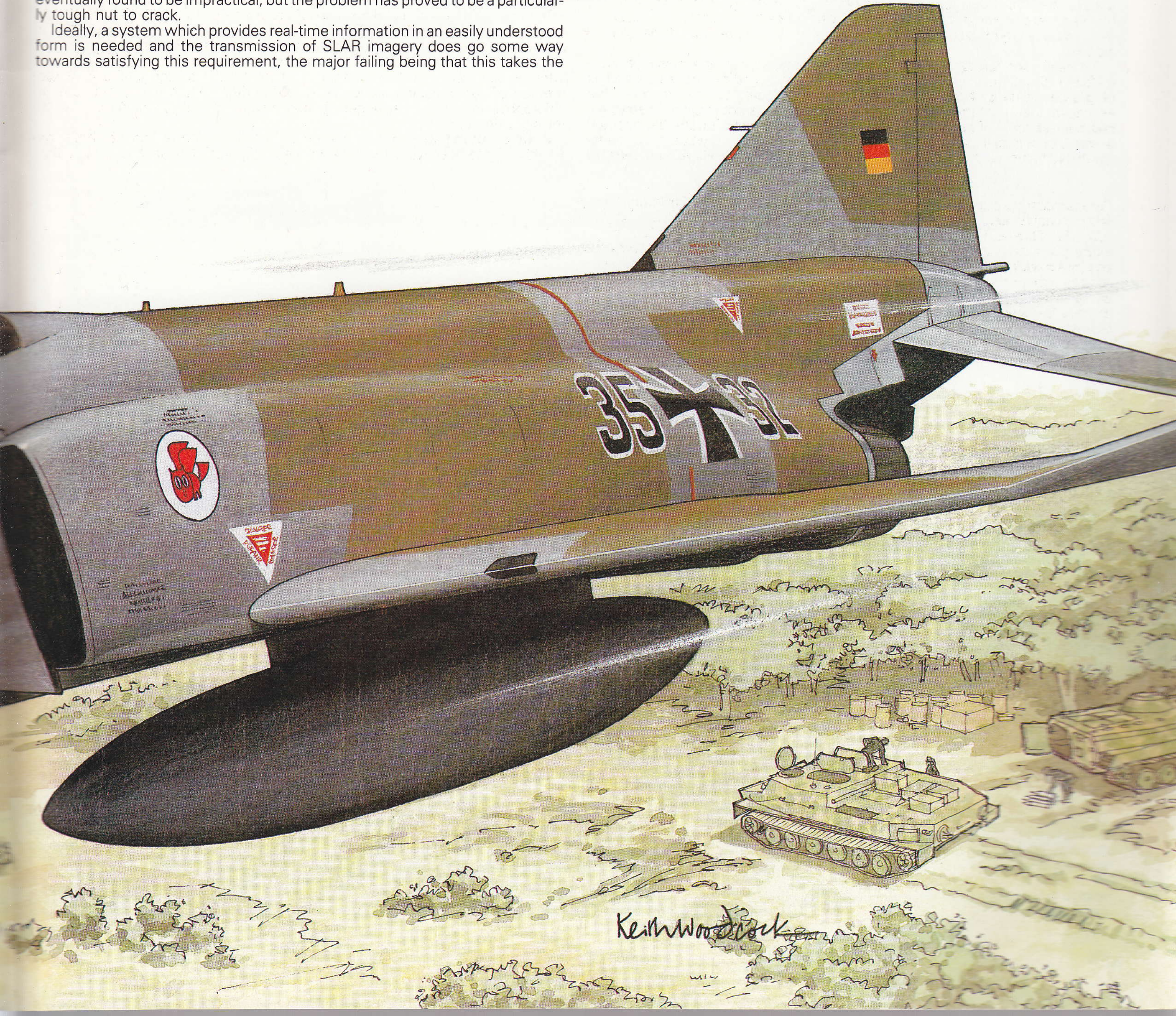
Perhaps the greatest stumbling block in the art of reconnaissance centres around the processing and distribution of intelligence. In the RAF, the interpretation of data obtained by Jaguar reconnaissance aircraft can be under way within just 10 minutes of touch-down, it being possible to furnish field commanders with the results in about 30 minutes. However, modern warfare can be accomplished at bewildering speed and even a 30-minute delay could prove catastrophic to those forces operating on the ground.

Numerous attempts have been made to overcome this difficulty: for instance, early production RF-4C Phantoms incorporated a system whereby film cassettes were ejected in flight adjacent to a processing centre. Such a facility was eventually found to be impractical, but the problem has proved to be a particularly tough nut to crack.

Ideally, a system which provides real-time information in an easily understood form is needed and the transmission of SLAR imagery does go some way towards satisfying this requirement, the major failing being that this takes the form of radar 'blips' rather than a photographic image. Thus, it would be necessary to keep interpreters at command headquarters and, while they would undoubtedly be highly skilled at their particular task, they would rarely be privy to the 'big picture'. One promising solution to the problem of providing first-rate photographic imagery is, however, now under test with the US Air Force, this being the AN/UXD-1 system which permits high-quality pictures to be transmitted to ground command centres within just 10 seconds of their being taken. Understandably, development of this system is being pursued vigorously.

In addition to the specialist reconnaissance gathering aircraft mentioned above, virtually any type can assist in the battlefield surveillance task. In the case of the US armed forces, the army's Grumman OV-1 Mohawk and the air force's Rockwell OV-10 Bronco are very useful whilst Elint specialists are also of great value in that they can detect, identify and pinpoint threats such as enemy radars. Comint/Sigint (communications/signals intelligence) gathering aircraft such as the Beech U-21 also have a valid part to play by their ability to intercept messages which, if decoded quickly by cryptoanalysts, could provide first-rate intelligence of enemy intentions and objectives.

In conclusion, it is clear that reconnaissance can take many forms, and it is only by taking into account all of these interwoven strands that the field commander can obtain an accurate overview of the battle in progress and, more important, reach the correct conclusions over the disposition and employment of his own resources.



USA

Northrop RF-5

The diminutive but highly successful **Northrop F-5 Freedom Fighter/Tiger** family has also been developed to perform photographic reconnaissance duties; approximately 100 examples of the **RF-5A** and **RF-5E Tigereye** have been built to date.

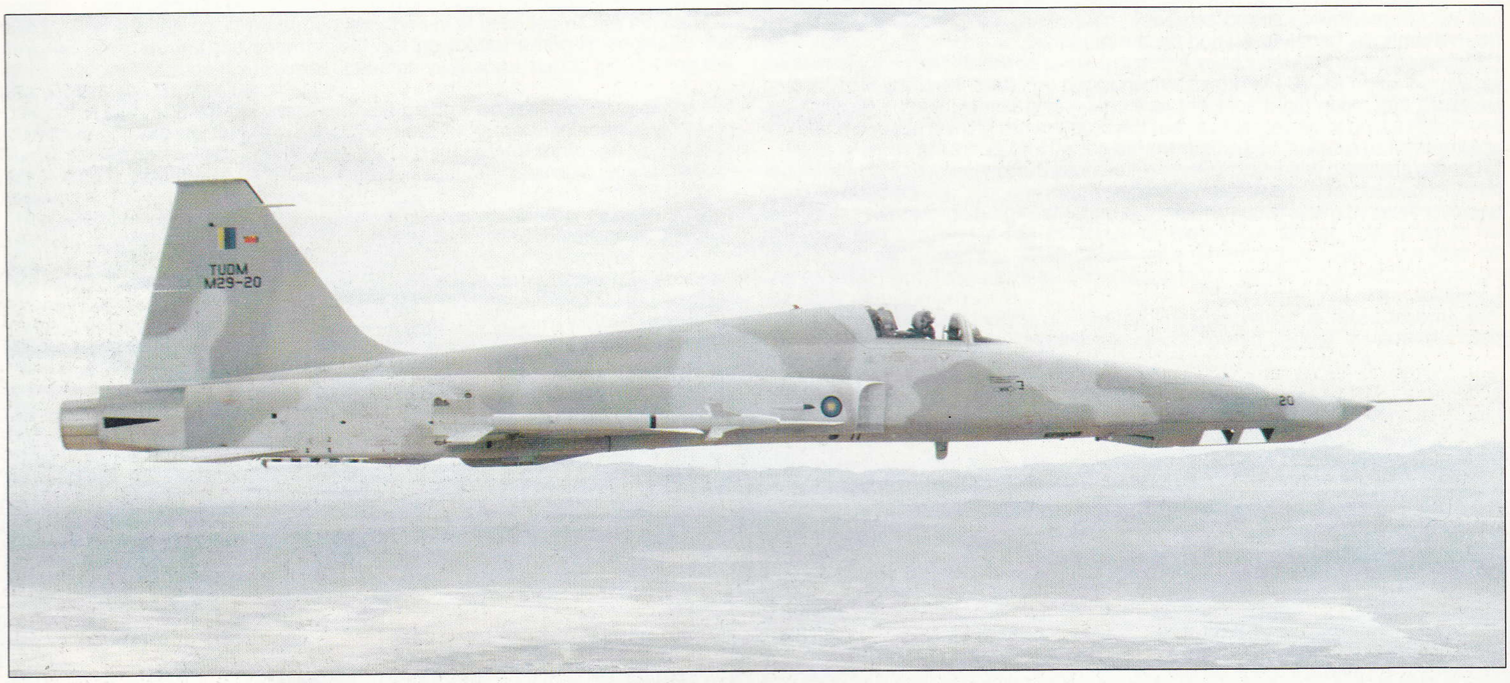
The first and thus far most numerous reconnaissance model to appear was the RF-5A, 89 examples of which were constructed by the parent company between 1967-72. Featuring a nose-mounted battery of four KS-92A cameras, the RF-5A entered development in October 1963 in response to a US Air Force directive calling for a daylight tactical reconnaissance model of the Freedom Fighter for supply to friendly nations as part of military assistance and foreign military sales programmes.

The RF-5A flew for the first time during May 1968, deliveries beginning during the following month with the initial aircraft going to Iran, which received 13 production examples as part of the military aid programme then in being. Subsequent customers comprised Turkey (20 aircraft), South Vietnam (10), Thailand (4), Greece (16), South Korea (8), Morocco (2) and Norway (16) before production of this model ceased in June 1972.

In addition to those aircraft produced by the parent company, the Freedom Fighter was also built under licence in Spain, 17 examples of the reconnaissance model known locally as the **SRF-5A** being completed by CASA whilst many of the 89 **CF-5As** and **75 NF-5As** completed by Canadair for service with the armed forces of Canada, the Netherlands and Venezuela also featured latent reconnaissance capability, being fitted with camera noses.

More recently, Northrop has developed the **RF-5E Tigereye** for reconnaissance duties and this is a rather more sophisticated machine based on the F-5E Tiger II and using up to six cameras or infra-red scanners on quick-change pallets which can be inserted into the extended nose. Making its maiden flight on 29 January 1979, the RF-5E has thus far failed to find a ready market, the only customers being Malaysia, which took delivery of two during 1983, and Saudi Arabia, which has ordered 10.

Specification
RF-5A
Type: single-seat tactical reconnaissance aircraft
Powerplant: two General Electric J85-GE-13 turbojets each rated at 1851-kg (4,080-lb) afterburning thrust
Performance: maximum speed at 10975 m (36,000 ft) 1489 km/h (925 mph) or Mach 1.4; combat ceiling 15240 m (50,000 ft); range 2595 km (1,612 miles)
Weights: empty 3667 kg (8,085 lb); maximum take-off 8952 kg (19,736 lb)
Dimensions: span 7.70 m (25 ft 3 in); length 14.38 m (47 ft 2 in); height 4.01 m (13 ft 2 in); wing area 15.79 m^2 (170 sq ft)



Malaysia operates two Northrop RF-5E Tigereyes on reconnaissance duties, equipped with Sidewinder air-to-air missiles on the wingtips for protection. The type features a redesigned nose and an arrester hook in common with most US fighters.

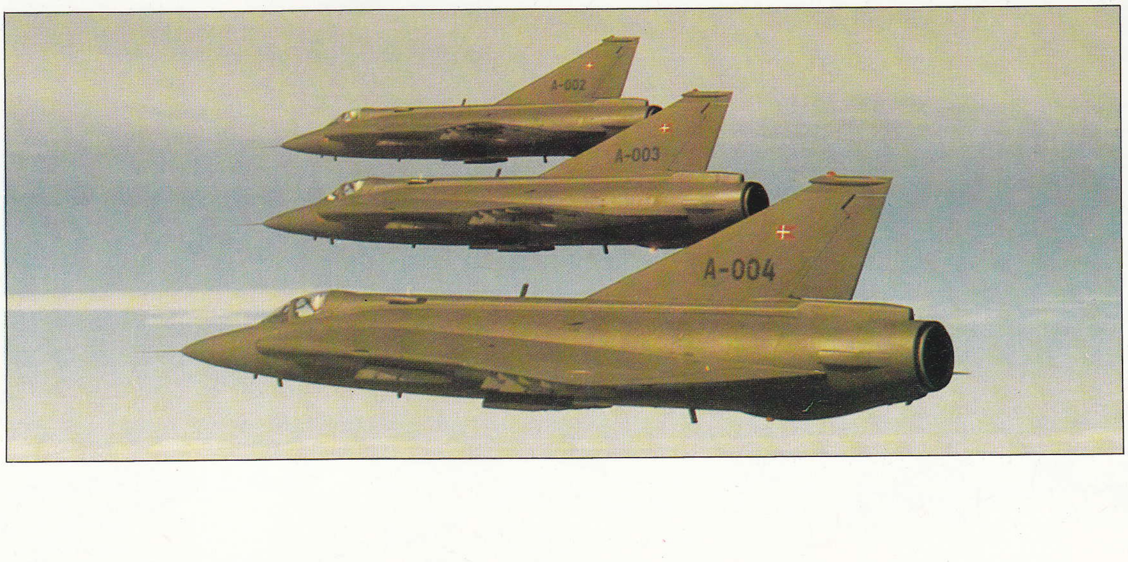
SWEDEN

Saab 35 Draken

Flying for the first time on 27 June 1963, the **Saab S35E** is a variant of the distinctive double-delta Draken (dragon) interceptor, optimized for the tactical reconnaissance role and able satisfactorily to perform low-, medium- or high-altitude reconnaissance by day or night. Essentially similar to the J35D fighter, the S35E features a battery of forward-facing, vertical and oblique cameras in a redesigned nose section, the entire outer shell of which slides forward to permit rapid access and thus facilitate removal and replacement of camera magazines.

Entering service with the Swedish air force's Flygflottilj 11 in the mid-1960s, the S35E served as the Flygvapen reconnaissance workhorse for many years, although it has now been largely supplanted by a version of the Viggen. Some 60 examples of the S35E were produced, this figure being fairly evenly split between new-build airframes and reconfigured J35Ds, whilst a further 20 reconnaissance Drakens were produced for the Royal Danish air force (forming part of the total of 52 Drakens acquired by Denmark in the early 1970s) and being known by the designation **RF35** in that country's service. With the exception of a handful of attrition losses, all are still in service today, equipping Eskadrille 729 at Karup. In company parlance, the machines are known as the **S35SD**, the basic Saab 35X being a derivative of the definitive J35F interceptor earmarked for the export market.

Specification
S35E/RF35
Type: single-seat tactical reconnaissance aircraft
Powerplant: one Svenska Flygmotor RM6C turbojet rated at 7760-kg (17,108-lb) afterburning thrust



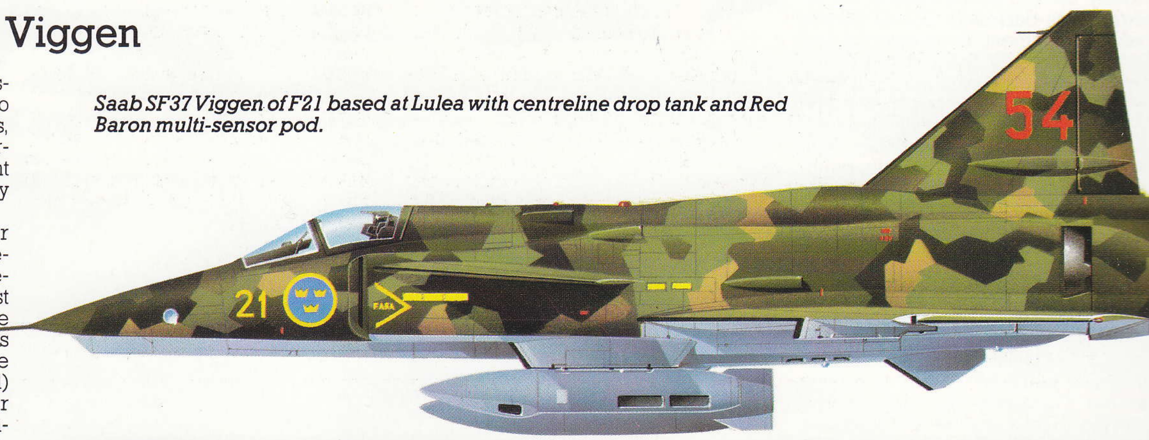
Danish Drakens are used in the tactical reconnaissance role when fitted with external pods. Another version, the S35E (RF-35 in Denmark), has a full camera nose with provision for up to five OMERA cameras.

Saab 35 Draken (continued)

Performance: maximum speed 2125 km/h (1,320 mph) or Mach 2.0; range on internal fuel about 1290 km (800 miles); maximum range 3250 km (2,020 miles)
Weights: empty 8245 kg (18,180 lb); maximum take-off 16000 kg (35,275 lb)
Dimensions: span 9.40 m (30 ft 10 in); length 15.85 m (52 ft 0 in); height 3.89 m (12 ft 9 in); wing area 49.20 m² (529.6 sq ft)

SWEDEN

Saab-Scania Viggen



Saab SF37 Viggen of F21 based at Lulea with centreline drop tank and Red Baron multi-sensor pod.

Undoubtedly one of the most impressive and capable combat aircraft to emerge in the past couple of decades, the **Saab-Scania 37 Viggen** (thunderbolt) is available in several different sub-types, two of which are principally engaged in reconnaissance duties.

To fulfil Flygvapen (Swedish air force) requirements in the tactical reconnaissance area, the **SF37** was developed, and this features the almost obligatory camera nose in place of the radar doppler fitted to other members of the Viggen family. An impressive array of cameras (totalling seven in all) is provided, comprising four vertical or oblique units for low-level photography, two vertical cameras for medium- to high-altitude tasks, and a solitary infra-red camera. Additional capability is provided by pod-mounted systems as and when required, such facilities enhancing both day and night reconnaissance potential and including additional specialized cameras and Red Baron infra-red linescan equipment. Ordered into production early in 1973, the SF37 variant flew for the first time on 21 May of the same year, with deliveries to the first operational unit, F21 at Lulea, beginning during April 1977. This model replaced the same company's S35E Draken in Swedish air force service.

The other reconnaissance derivative of the Viggen is the **SH37** which is optimized for maritime applications. Featuring a special long-range, forward-facing camera contained in a fairing located beneath and slightly aft of the starboard engine air inlet, this model unlike the SF37 retains a nose-mounted radar for surveillance purposes and it can also operate with additional sensors or weaponry. Replacing the S32C Lansen, the SH37 prototype made its maiden flight on 10 December 1973, production specimens being delivered from June 1975. This sub-type is now active with at least two Flygvapen units.

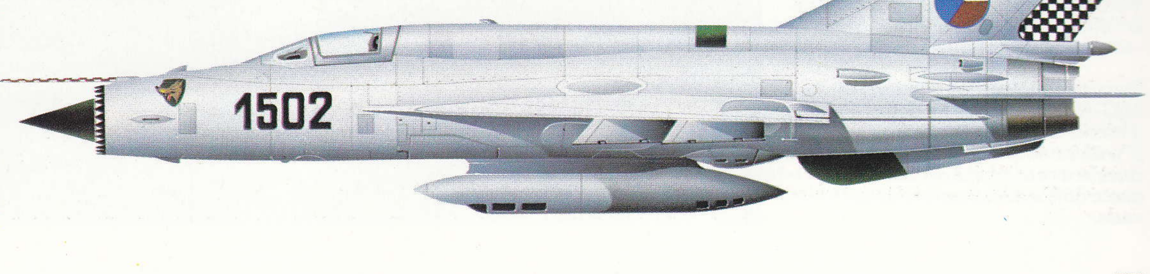
Air-to-air missiles can be carried by both of these derivatives for self-defence purposes.

Deleting the radar of earlier models, the SF37 carries four low-level, two high-altitude and an infra-red camera in its nose. It can also carry ECM pods, Red Baron pods and attack weaponry. This example is from F13 at Norrköping.

Specification
SF37/SH37
Type: single-seat tactical reconnaissance/maritime surveillance aircraft
Powerplant: one Volvo Flygmotor RM8A turbofan rated at 11800-kg (26,015-lb) afterburning thrust
Performance: maximum speed at altitude 2125 km/h (1,320 mph) or Mach 2.0; tactical radius more than 1000 km (621 miles)
Weights: empty 9000 kg (19,840 lb); maximum take-off 20500 kg (45,195 lb)
Dimensions: span 10.60 m (34 ft 9¼ in); length 16.30 m (53 ft 5¼ in); height 5.80 m (19 ft 0¼ in); wing area 46.00 m² (495.1 sq ft)

USSR

Mikoyan-Gurevich MiG-21R 'Fishbed'



Mikoyan-Gurevich MiG-21R (sub-model unknown) of the Czech air force, carrying a centreline reconnaissance pod.

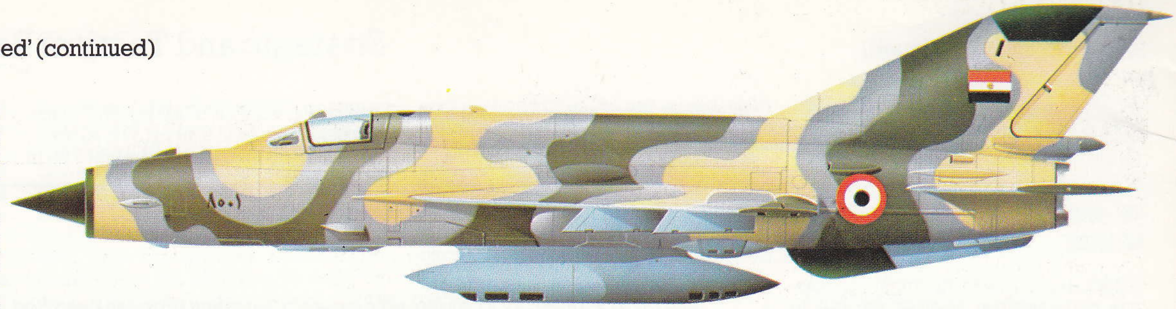
Without doubt the most widely used and prolific fighter aircraft of the post-World War II era, the **Mikoyan-Gurevich MiG-21 'Fishbed'** remains in quantity production today, albeit in a very different form from that of its debut during the mid-1950s, and it has almost inevitably spawned a number of reconnaissance derivatives which feature varying sensor packages.

The original reconnaissance model was the **MiG-21R** (based on the MiG-21PFMA which introduced the large dorsal spine, now a common feature of

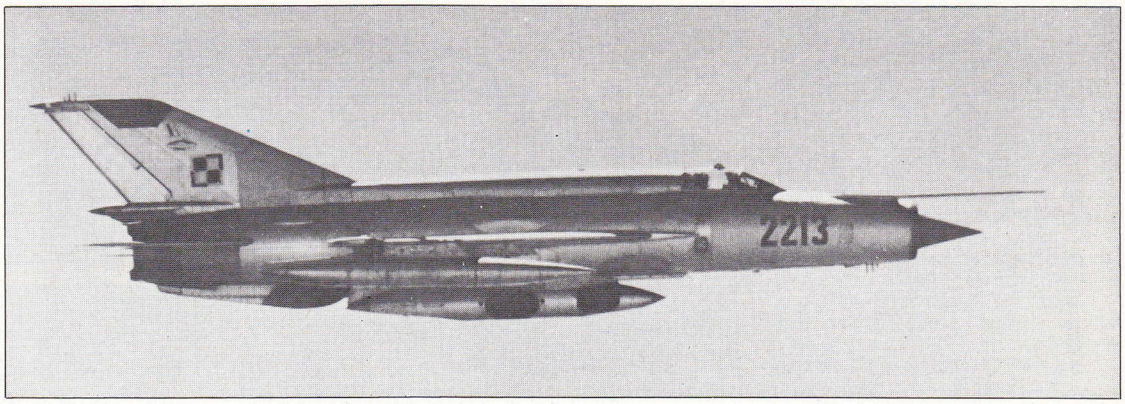
Mikoyan-Gurevich MiG-21R 'Fishbed' (continued)

the 'Fishbed'), produced in several sub-types with equipment ranging from basic internally-mounted optical cameras (occupying the area previously used to accommodate the integral twin-barrelled GSh-23 23-mm cannon armament) to an external pod system known to house forward and oblique cameras plus infra-red line-scan apparatus. Powered by a single Tumansky R-11 turbojet, all variants of the MiG-21R can also operate with wingtip-mounted electronic countermeasures pods and it would seem reasonable to assume that K-13A 'Atoll' or AA-8 'Aphid' air-to-air missiles can also be carried to provide a measure of self-defence capability where the threat from hostile fighters is high.

More recently, the principal 'Fishbed' reconnaissance derivative has been the **MiG-21RF** which is essentially similar to the MiG-21MF in relying on the Tumansky R-13-300 engine offering greater power and featuring increased airflow despite being no larger. Sensor packages and equipment are probably the same as those incorporated in the earlier MiG-21R variant.



Above: MiG-21R sporting the three-colour camouflage of the Egyptian air force, with internal cameras (behind the nosewheel) as well as the underfuselage pod.



Mikoyan-Gurevich MiG-21R 'Fishbed-H' of the Polish air force. This model is based on the MiG-21MF with the addition of a centreline sensor pod and the replacement of the cannon pack with a further three cameras.

Specification
MiG-21RF
Type: single-seat tactical reconnaissance aircraft
Powerplant: one Tumansky R-13-300 turbojet rated at 6600-kg (14,550-lb) afterburning thrust
Performance: maximum speed at sea level 1300 km/h (810 mph) or Mach 1.06; maximum speed at altitude 2230 km/h (1,385 mph) or Mach 2.1; service ceiling 17500 m (57,400 ft); range with maximum fuel 1670 km (1,038 miles)
Weight: maximum take-off 9400 kg (20,723 lb)
Dimensions: span 7.15 m (23 ft 5½ in); length 15.76 m (51 ft 8½ in); height about 4.06 m (13 ft 4 in); wing area 23.00 m² (247.6 sq ft)

USSR

Mikoyan-Gurevich MiG-25R 'Foxbat'

Evolution of the **Mikoyan-Gurevich MiG-25 'Foxbat'** began in about 1958, initially in response to the anticipated threat represented by the North American B-70 Valkyrie strategic bomber. Despite the 1961 Presidential decision to employ the latter type only for research duties, work on the 'Foxbat' continued, though greater emphasis was then placed upon reconnaissance potential. Accordingly, to date, two of the five variants which have been identified are primarily intended for reconnaissance duties.

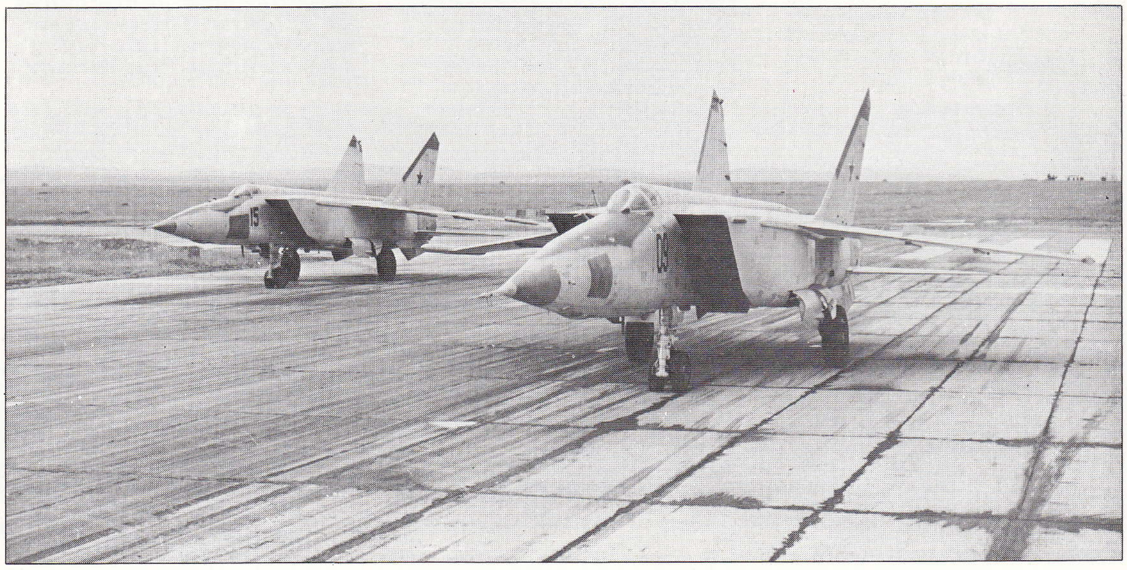
Flown in prototype form in about 1964, the 'Foxbat' is believed to have entered operational service during 1970 and, despite the fact that much of the avionics equipment is typical of the era when it was designed, it is nevertheless a most potent interceptor and over 300 examples of the 'Foxbat-A' interceptor are now in service with home defence elements of the Voyska PVO while others have been exported to Algeria, Libya and Syria.

The first reconnaissance derivative to appear was the **MiG-25R 'Foxbat-B'**, which features a total of five vertical/oblique cameras in the nose section ahead of the cockpit. SLAR (Side-Looking Airborne Radar) apparatus is also installed in the forward fuselage, whilst this model and the later **'Foxbat-D'** both employ a different wing of shorter span than that of the interceptor.

The 'Foxbat-B' is also thought to have entered service in 1970, and it is known that four Soviet air force aircraft of this type were deployed to Egypt in the spring of 1971, making a number of forays from Cairo West to conduct reconnaissance sorties over the Israeli-occupied Sinai peninsula and down Israel's coast. Israeli attempts to intercept these with McDonnell Douglas F-4E Phantoms met with no success, and the MiG-25Rs remained in Egypt until the autumn of 1975.

The 'Foxbat-B' was followed in due course by the 'Foxbat-D', the latter being generally similar in appearance although it lacks the camera installation and also incorporates a somewhat larger SLAR, this being located slightly farther aft and much closer to the cockpit. Recent estimates indicate that a combined total of about 160 examples of the 'Foxbat-B' and 'Foxbat-D' models are at present active with Soviet tactical air forces, further machines having been supplied to Algeria, India, Libya and Syria since 1979.

Specification
MiG-25R
Type: single-seat all-weather tactical/strategic reconnaissance aircraft
Powerplant: two Tumansky R-31 turbojets each rated at 11000-kg (24,250-lb) afterburning thrust
Performance: maximum speed 3400 km/h (2,115 mph) or Mach 3.2; service ceiling 27000 m (88,580 ft); normal operational radius 1095 km (690 miles); ferry range 2575 km (1,600 miles)
Weights: empty 19595 kg (43,200 lb); maximum take-off 33400 kg (73,635 lb)
Dimensions: span 13.40 m (44 ft 0 in); length 23.82 m (78 ft 1¾ in); height 6.10 m (20 ft 0¼ in); wing area 56.00 m² (603 sq ft)



Two reconnaissance versions of the MiG-25 together: on the left is a 'Foxbat-D' and on the right a 'Foxbat-B' with smaller SLAR. The 'D' model does not carry cameras but houses electronic sensors as well as its radar.

French Navy

The French Navy (or Marine Nationale) today challenges the claim of the Royal Navy to be the biggest navy in Western Europe, with a modern balanced force which includes aircraft-carriers, strategic nuclear submarines and amphibious warfare ships.

It is a far cry from the motley collection of ex-German, ex-British and worn-out pre-1939 ships which made up the French fleet in the 1950s. A vigorous programme of new construction rectified this state of affairs, and as French industry was painfully rebuilt after World War II it became possible to rely more and more on indigenous guns, missiles and electronics. During this period there was, of course, the war in Indo-China. Although it ended in a military debacle at Dien Bien Phu, the war gave the navy's carrier pilots much useful experience and convinced senior officers of the value of carriers.

Today the fleet of the 1960s is being replaced. The old destroyers have been phased out, and work has begun on the first of two 30,000-ton nuclear carriers to replace the *Foch* and *Clemenceau.* In accordance with General de Gaulle's policy of total autonomy, a force of ballistic missile submarines (SSBNs, or SNLEs in French parlance) has been built up, with five boats in service, a sixth building and the seventh projected. Each one deploys 16 French-made MSBS ballistic missiles, but the M-1 and M-2 missiles have been replaced by the M-20, which is in turn being replaced by the M-4 version, with greatly improved penetration aids and longer range.

Although nuclear propulsion was available for the SNLEs as far back as 1964, another 12 years elapsed before the first French nuclear hunter-killer submarines were laid down. A large number of conventional diesel-electric submarines was built from the 1950s onwards, and units of the 'Daphné' class were also sold to a number of overseas navies. The latest diesel-electric boats are the four 'Agosta' class, which have the same type of weapons as the nuclear-powered 'Rubis' class. Two of the latter are now in service and four more are planned.

The main strike capability of the fleet is provided by the Super Etendard aircraft, operating from the carriers* Clemenceau and Foch. *They are to be replaced by nuclear-powered vessels in the 1990s.

The main striking force of the Fleet comprises the carriers *Foch* and *Clemenceau* (32,000 tons) which were completed in the early 1960s. They operate a maximum of 40 aircraft and have recently been modernized to take Dassault-Breguet Super Etendard strike aircraft. These are also capable of deploying tactical nuclear weapons, and carry the AM.39 Exocet air-to-surface missile. Plans to build a nuclear helicopter carrier were announced as long ago as 1970, but this ship has been deferred to 1988, and as two nuclear carriers have been approved it is possible that this ship will never be built, Sea Harriers vanishing with it.

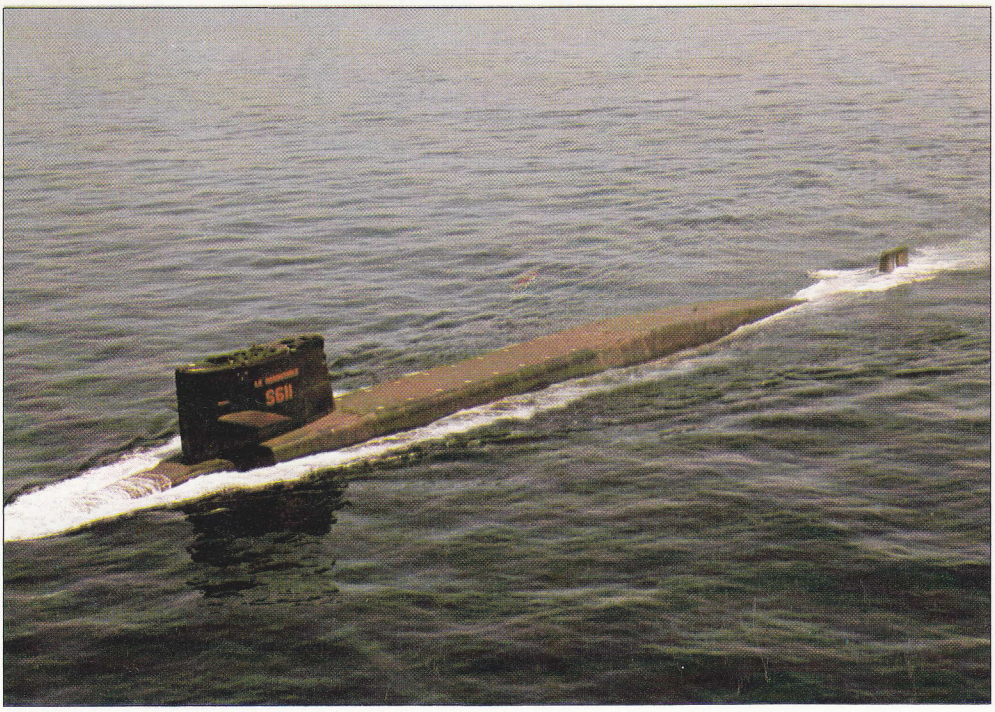
The only other aircraft-carrier is the interesting hybrid helicopter-cruiser *Jeanne d'Arc* (10,000 tons). Built in 1960-4 as replacement for a pre-war training cruiser of the same name, she functions as a cadet training ship in peacetime and as an ASW helicopter carrier or assault ship in wartime. Although she normally operates a mixture of light helicopters in peacetime her wartime complement is eight Aérospatiale Super Frélon large helicopters.

Apart from the carriers, the largest French surface combatant is the air-defence cruiser *Colbert.* Commissioned nearly 25 years ago, she was rearmed with Masurca medium-range surface-to-air missiles in 1970-2, and has since had four MM.38 Exocet anti-ship missiles added. In view of her age she is not likely to be replaced, and she absorbs a large number of skilled technicians. However, she has extensive command facilities and will be retained for some years.

Several of the destroyers built in the 1950s remain in service, including two 'T 47' class armed with the American Standard (MR) SM-1 missile for air defence, and seven armed for anti-submarine warfare. They are steadily being replaced by new construction, but the high cost of modern warships rules out any hopes of one-for-one replacement.

In the late 1960s and early 1970s a number of large and powerful escorts were built. For air defence there were two 5,000-ton destroyers armed with the Masurca SAM, the *Suffren* and *Duquesne;* ASW capability was provided by the 3,500-ton corvette *Aconit* and the three 'Tourville' class frigates. All but *Aconit* have been retrofitted with the MM.38 Exocet, but she will receive the longer-range MM.40 version shortly. The 'Tourville' class have also received the new Crotale point-defence missile system.

The next generation of anti-submarine escorts are the units of the 'Georges Leygues' class. Called 'corvettes', they correspond to frigates or destroyers in other navies and have D-numbers. They have a hull-mounted sonar at the bow and a large variable-depth sonar aft, in common with earlier ASW ships, but also carry four Exocet anti-ship missiles and the Crotale SAM system. They are unique among French warships in having Rolls-Royce Olympus gas turbines for main drive, linked to diesels for cruising. Three of the class are in service, one is under construction and two more are planned.



Le Redoutable, *the first SSBN operational with the Marine Nationale, is soon to be armed with the improved M-4 missile. The M-4 has a range of more than 4000 km (2485 miles) and an MRV warhead.*

Commissioned in 1970, Duquesne *is the second 'Suffren' class destroyer in service. Armed with Masurca SAMs, Exocet SSMs and guns,* Duquesne *is a fine sea boat and weapon platform.*

The 'Corvette 1970' or 'C 70' hull of the 'Georges Leygues' class forms the basis of a new class of air-defence destroyers intended to protect the carriers. The 'C 70AA' type, of which two are under construction and at least one more is planned, are to be armed with the American Standard (Medium Range) SM-1 missile, but with French tracker radars. The propulsion is to be a revolutionary new doubly-supercharged diesel, which has a high power-to-weight ratio. The ships will have the MM.40 version of Exocet and a new form of close-in or last-ditch defence against sea-skimming missiles.

Like other countries, France has been hit by the spiralling cost of new ships. To meet the needs of coastal escort 17 small *avisos* or light frigates of the 'd'Estienne d'Orves' or 'A 69' class have been laid down since 1972. On a displacement of only 1,200 tons these mount a 100-mm (3.9-in) gun and an anti-submarine rocket-launcher, and several have two Exocet missiles as well. They are a simple, rugged design useful for escort and patrol duties.

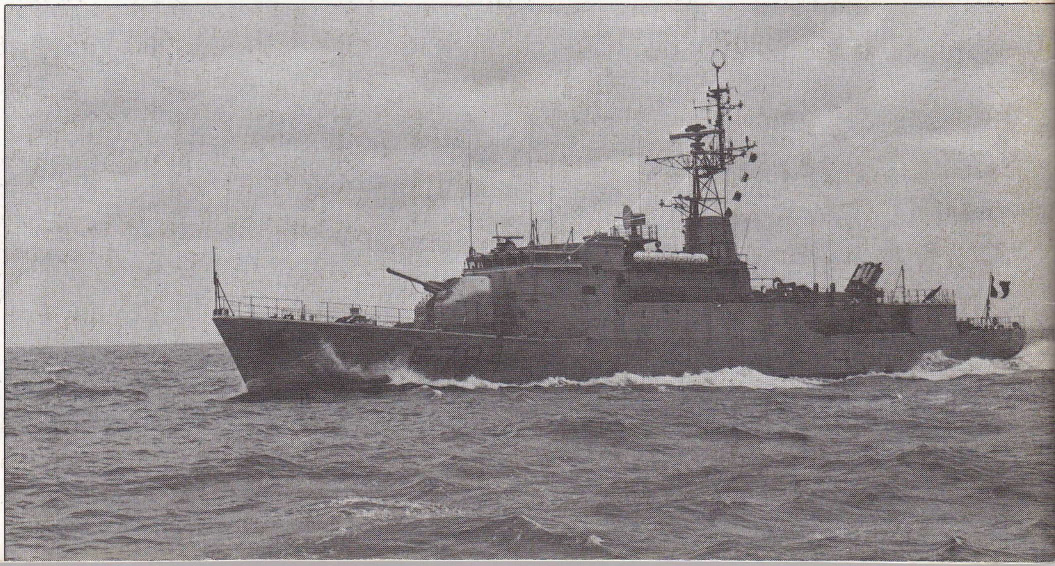
Amphibious warfare is served by two dock landing ships, the *Orage* and *Ouragan*, backed up by five LSTs, a new class of four LSMs and a number of smaller landing craft.

The other area of specialized warfare is mine countermeasures, a field in which France has shown considerable expertise. Under the Tripartite Minehunter Programme French designers drew up plans for a 500-ton glass reinforced plastic (GRP) minehunter for simultaneous construction in French, Belgian and Dutch shipyards. This 'Eridan' class (15 units building in France, 15 in the Netherlands and 10 in Belgium) has a French minehunting sonar, Dutch diesels and Belgian electrical systems. The first two French craft are at sea, as is the Dutch lead-craft, but the Belgian programme is some way behind. It is a remarkable example of international collaboration.

The French navy has clung tenaciously to the concept of a balanced fleet, capable of operating overseas when needed. Financial difficulties have slowed down the rate of ship-building, and it remains to be seen what effect the current national financial crisis has on the navy's plans to replace its carriers. What cannot be denied is France's determination to remain a front-rank naval power.

Order of battle

one 'L'Inflexible' class nuclear-powered ballistic-missile submarine on order (with one more planned)
five 'Le Redoutable' class nuclear-powered ballistic-missile submarines
one 'Gymnote' class experimental ballistic-missile submarine
two 'Type SNA 72' or 'Rubis' class nuclear-powered attack submarine (with another four building or planned)
four 'Agosta' class attack submarines
nine 'Daphné' class attack submarines
four 'Narval' class attack submarines
two nuclear-powered fleet aircraft-carriers planned
two 'Clemenceau' class fleet aircraft-carriers
one 'La Résolue' class helicopter-carrier
one 'Colbert' class guided-missile cruiser
three 'Type C 70' class anti-submarine corvettes (with one more building and another two planned)
two 'Type C 70AA' class AA guided-missile destroyers building and one more planned
two 'Suffren' class AA guided-missile destroyers
three 'Type F 67' class general-purpose guided-missile destroyer
one 'Type T 56' class anti-submarine destroyer
one 'Type T 53 (Modified)' class anti-submarine guided-missile destroyer
two 'Type T 47' class AA guided-missile destroyers
five 'Type T 47' class anti-submarine destroyers
one 'Type C 65' class general-purpose guided-missile destroyer
nine 'Commandant Rivière' class general-purpose guided-missile frigates
16 'Type A 69' or 'd'Estienne d'Orves' class coastal anti-submarine guided-missile frigates (with one more building)
two 'TCD' type landing ships, dock
three 'Batral' type landing ships, medium (with one more building and two more planned)
five 'BCD' type landing ships, tank
12 landing craft, tank (with one more building and one more planned)
30 landing craft, medium (with 10 more building)
two 'Super Patra' class fast attack craft (missile) (with six more on order)
four 'Patra' class fast attack craft (missile)
one 'La Combattante I' class fast attack craft (missile)
one 'Sirius' class large patrol craft
four 'La Dunkerquoise' class large patrol craft
four 'Eridan' class minehunters (plus six more building and five more planned)
five 'Circé' class minehunters
10 'Aggressive' or 'Ouistrehan' class coastal minesweepers
seven 'Pivoine' class coastal minesweepers
five 'Sirius' class coastal minesweepers



Detroyat *is an 'A 69' class coastal ASW frigate, and has been designed to be fitted with Exocet launchers. Like most of her sisters, however, she does not carry the weapon.*